A

TEXT-BOOK OF INDUCTIVE LOGIC.

WITH NUMEROUS EXERCISES.

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Preface.

The absence of a suitable text-book of Inductive Logic has been keenly felt ever since this subject was introduced into the Intermediate course. The works of Mill, Jevons, Fowler, Bain, Welton and others are no doubt standard works on the subject, but they are precisely for that reason not suited for class use. They cover far more ground than the Syllabus laid down for the Intermediate Examination; and they contain few or no exercises; and without exercises the teaching of Logic is as useless as the teaching of Mathematics without the solution of problems. I have therefore made it a point to append a set of exercises at the end of every Chapter, and made the treatment of Inductive Fallacies as exhaustive as I could. Many of the examples and exercises have been borrowed or adapted from the works of the great logicians; but a great many have been specially framed for this book.

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A. C. M.

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A

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INTRODUCTION.

Students who proceed to the study of Inductive Logic after completing their course in Deductive Logic, will be very much mistaken if they expect to find in it the treatment of Terms, Propositions and Syllogisms from what they would regard as the "inductive" point of view. Inductive Logic has very little in common with Deductive Logic. It is only in so far as both deal with the process of *inference* (in its widest sense) that both may be termed Logic; otherwise the proper name for what is traditionally called Inductive Logic would be "Principles of Experimental Science."

The term "inference" has a very wide meaning. It includes not merely syllogisms, but all forms of reasoning by which the mind arrives at some fresh truth as a consequence of some other or others already known. In Deductive Logic, the truths from which the reasoning starts are general or universal propositions which are taken for granted; in Inductive Logic, we have got to establish these universal propositions by examining particular instances. In Deduction, general

truths are presupposed as intuitions of the mind, or hypotheses, or knowledge taken on trust or authority; in Induction, the universal propositions from which deduction starts are arrived at by observation and experiment. Roughly, Deduction may be said to descend from general truths to particular facts; Induction, to ascend from particular facts to general truths. Or, to put the same thing in other words, in Induction we trace effects to their causes; in Deduction, causes to their effects. The process involved in both may in a broad sense be termed Inference.

But the relation between Deduction and Induction is not really one of opposition, but of mutual dependence: the one cannot be carried on without the other. Deduction depends on Induction, because the universal propositions which constitute its premisses are obtained by induction; Induction depends on Deduction, because in predicating of a whole class what we observe in particular cases, we actually employ deductive reasoning.

Strictly speaking, Induction comes before Deduction in the order of treatment, because we must first get premisses before we can reason syllogistically. Practically, however, it is more convenient to study Induction after Deduction, because a knowledge of Syllogisms is

useful in understanding the true nature of Induction and in realising its great importance.

The Scholastic philosophers of the middle ages believed that the only source of knowledge was the syllogism, and hence they neglected Induction, which received its first great stimulus from the time of Bacon, who is often styled "the Founder of the modern Inductive Philosophy." The syllogism is no doubt a very useful form of argument, but it cannot yield us any new truths. General truths cannot always be proved by syllogisms ; because to prove a universal proposition by a syllogism, the premisses of the syllogism must be universal propositions ; and then to prove these premisses we must have fresh syllogisms with universal propositions again as their premisses, and so on until a point is reached beyond which we cannot proceed at all. For example, take the universal proposition, *All men are mortal* : we can prove it by the following syllogism :—

All animals are mortal,
All men are animals,
∴ All men are mortal.

The major premiss of this syllogism again may be proved by another syllogism, having for its own major a still wider universal :—

All composite bodies are subject to dissolution,
All animals are composite bodies,
∴ All animals are subject to dissolution, *i.e.*, mortal.

But there must be a limit to this process: the series cannot go on *ad infinitum.* Hence Logic accepts certain principles as conditioning all reasoning, and obtains most of its general propositions, if they have any scientific grounds, by induction from observed facts, with the aid of these ultimate principles. These ultimate principles form the subject-matter of Inductive Logic.

CHAPTER I.

THE NATURE OF INDUCTIVE INFERENCE.

1 **Definition of Induction.**—"Induction is that operation of the mind by which we infer that what we know to be true in a particular case or cases, will be true in all cases which resemble the former in certain assignable respects."

—*Mill.*

"Induction is the process by which we conclude that what is true of certain individuals of a class is true of the whole class, or that what is true at certain times will be true in similar circumstances at all times."

—*Mill.*

"Induction is the process of arriving at general propositions by means of observation or fact."

—*Bain.*

2 **Three Essentials of Induction.**—There are three essential marks of a true induction :—

(1) An induction must be expressed in the form of a *proposition* ; it is an affirmation of concurrence or non-concurrence.

(2) The proposition must be *general*, that is, applicable to all cases of a given kind.

(3) The mode of arriving at it must be an appeal to *observation* or fact.

Each of these essentials will now be explained more fully.

3 An Induction is a Proposition.—An induction must be expressed in the form of a logical proposition, affirming a coincidence or non-coincidence of distinct properties; that is to say, the proposition must be a real proposition, not a verbal one. A verbal proposition gives only the definition or part of the definition of the subject; a real proposition states some fact about the subject which is not contained in its definition.

An Induction should therefore be distinguished from a General Notion or Definition. In forming a general notion or in framing a definition the mental process is to some extent the same as in Induction: in both we ascend from particulars to general. But both in Notion and in Definition we are absolutely limited to *one* indivisible fact or attribute, whereas in Induction there is a conjunction of *at least two* separate facts or attributes. For example, the proposition 'Ruminants are animals that chew the cud' is not an induction, because both subject and predicate refer to one and the same fact; whereas the proposition 'All ruminants are herbivorous' is an induction, because the attribute of chewing the cud is conjoined to the attribute of feeding on herbs in an affirmation of coincidence.

4 **An Induction is a General Proposition.**—An induction must not only be expressed in the form of a real proposition, but must also be a *general* proposition. A single concurrence, as 'The wind is shaking the tree,' is a proposition, and a real proposition, but not an induction. Induction is based on such individual concurrences, but a single one is not enough. If the concurrence recurs, or if the two things—a high wind and the shaking of trees—have concurred within the whole course of our observation, or if the same concurrence has been uniform in the observation of all other persons, we are then justified in saying, 'Every time there was a high wind the trees were shaken.' But still this is not an induction. What remains is the extension of the concurrence from the observed to the unobserved cases,—to the future, as well as to the past. *A complete induction is a generalisation that expresses what is conjoined everywhere and at all times.*

The generality of an inductive proposition may be wide or narrow, the *degree* of generality being quite immaterial. For example, 'The breeze always spreads the flag over Government House, Allahabad,' is as truly an induction as the much wider statement, 'The breeze always spreads all flags of all kinds,'—because both these statements are general, and cover the unseen and the future as well as the seen and the present.

Under this head a distinction should be drawn between Induction and what has been improperly called *Induction by simple Enumeration.* In the latter, a general proposition is used only to sum up the observed particulars. For example, if by enumerating the months of the year from January to December, we say 'All the months of the year have less than 32 days', this would not be an induction, because the statement is based on an observation of *all* the months; whereas in a true induction the general statement must advance *beyond* the observed particulars, for without such an advance there is no real inference, no addition to our knowledge.*

5. An Induction is based on Observation of Facts.—An inductive inference is based on direct observation of facts: it is not derived from other propositions. In this lies the chief point of difference between Induction and Deduction. Inductive propositions are obtained directly from Nature; deductive inferences are derived from propositions that are themselves inferences.

For example, the universal propositions of mathematics cannot be called inductions in the true sense, because although they are general and are based on a

* For a fuller treatment of this distinction between true and apparent inductions, see Chapter VII.

sort of observation, the observation is not observation of *concrete facts*, but calculation of *abstract quantities*. When, for example, Euclid proves that the angles at the base of an isosceles triangle are equal, his proof is not based on observation of concrete triangles (if there be such a thing in existence), but consists of demonstration made upon an exemplary diagram and thence extended to all similar instances. The only resemblance that this form of reasoning bears to Induction lies in extending what is found in one instance to all similar instances: the resemblance fails on vital points. We expressly omit from the reasoning all reference, say, to the size of the triangle, to its colour, to its material, to the size of the angle contained by the two equal sides,—that is to say, all elements of *observation*. This sort of inference is called "*Parity of Reasoning.*"

Induction should also be distinguished from "Colligation of Facts." 'Colligation' means the act of bringing into connection a number of isolated facts by means of a generalisation. Every induction is a colligation of facts, but every colligation of facts is not an induction. For example, the astronomer Kepler wished to discover in what kind of path the planet Mars moved. He could not observe its progress all along the path, but he made a number of detached observations as to the apparent places occupied by the planet. The

question for Kepler was what kind of figure the places between the points would make, supposing they were all joined together. After a good deal of unsuccessful guessing, Kepler concluded that an ellipse exactly suited the case. But the judgment, 'the path in which the planet Mars moves is an ellipse' is not an induction, but a mere colligation of facts, because although based on observation of concrete facts it is not based on causation : it is only a description in general terms of a set of observed phenomena.

Take another example. Suppose a navigator, after sailing round some newly-discovered land, observes that various parts of the coast are washed by the sea, and he draws the conclusion that it is an island. This too is not an induction. For in the first place the proposition is not general, but refers to an individual land. In the next place, though based on observation, the observation does not furnish a clue to any causal connection, but affords only a conception to fit certain facts. We thus see that mere observation of facts will not make an induction : *the observation must be with a view to discovering causal connection.*

6 Induction relies on the Uniformity of Nature.—As every true induction is an inference "from the known to the unknown" it assumes that the facts unobserved are essentially similar to the facts

observed—that what holds true of the particular cases that have been examined holds true of all similar cases. This we do on the strength of our belief in the uniformity of Nature. For example, we observe in the case of some animals and plants—say, our domestic animals and our garden plants—that they live and grow when they get a sufficient supply of light and heat, and languish or die when they do not. From the observation of these particular instances we infer that what we have found true in the case of certain animals and plants, will also be true in the case of other animals and plants. How do we draw such an inference?—On the ground of our belief in the uniformity of Nature. Hence our conclusion, 'All life depends on the presence of light and heat,' is a true induction, because it fulfils all the conditions of a true induction:—

(1) it is a real proposition,
(2) it is a general proposition,
(3) it is based on the observation of particular concrete instances,
and (4) it passes from the known to the unknown in reliance on the uniformity of Nature.

This last condition is a fourth essential of a true Induction, which may now be defined as *a universal real proposition, based on observation, in reliance on the uniformity of Nature.*

7. The Uniformity of Nature.—The uniformity of Nature has been expressed in the form of various sayings :—

> 'What has been will be.'
> 'History repeats itself.'
> 'The future will resemble the past.'
> 'The absent is like the present.'
> 'The universe is governed by laws.'

All these statements mean that what has been found true of anything under a certain set of circumstances will continue to be found true of similar things under similar sets of circumstances. The uniformity of Nature does not mean that Nature is uniform in all things, for in many ways she is far from uniform : there is endless variety in the sizes, shapes, colours, and all other properties of things. The wind and weather are proverbially inconstant. Yet amidst this infinite diversity there is a certain regularity and constancy in the nature of every phenomenon *in its own sphere.* Thus the propositions that 'Unsupported bodies fall to the ground,' that 'Arsenic is poisonous', that 'Water seeks its own level', are propositions that are uniformly true, whatever diversity there might be in the properties of these things under special circumstances ; *e.g.*, the unsupported body might be a stone, a coin, or a feather ; the arsenic may be white or black, crude or

refined ; the water may be rain water, or pipe water, or spring water. These are matters of detail that do not affect the course of nature. Hence it appears that there is not *a* uniformity, but *uniformities.* Different things fall under different departments, and each department has its own uniformities or laws. The course of nature is said to be uniform, because the course of each of the various phenomena that compose nature is uniform.

8 **The Law of Uniformity is held to be the ultimate Major Premiss of Inductions expressed in Syllogistic Form.**—Archbishop Whately holds that every inductive inference may be regarded as a syllogism with the major premiss suppressed, and that this major, when supplied, will be found to assert that what holds true of the cases under consideration will hold true of all similar cases ; that is, this major premiss is a statement of the Law of Uniformity. Thus, when having found that this, that, and the other magnet attract iron, we advance to the general proposition 'All magnets attract iron,' our reasoning may be expressed in the form of a syllogism as follows :—

> " Whatever holds true of this, that, and the other magnet, holds true of all,
>
> Attracting iron holds true of this, that, and the other magnet,
>
> ∴ Attracting iron holds true of all magnets."

Now, the assumed major here is not self-evident. How do we come by it? It is plain that it rests for its evidence on the large assumption of uniformity in the course of nature. While the *immediate* major premiss in every particular case of induction is the affirmation of some particular kind of uniformity, the *ultimate* major premiss of inductive syllogisms in general is the Law of Uniformity itself.

9. **Criticism of Archbishop Whately's View.**—Archbishop Whately's view that the Law of Uniformity is the ultimate major premiss of inductive syllogisms, is erroneous. Take the syllogism he offers as an illustration of his doctrine—

> "Whatever holds true of this, that, and the other magnet, holds true of all,
> Attracting iron holds true of this, that, and the other magnet,
> ∴ Attracting iron holds true of all magnets."

The minor premiss in the above syllogism is itself the statement of a universal law, and not the statement of particular instances of a phenomenon. For if, when it is said that in the instances examined the magnets attract iron, it be left uncertain whether the magnets *as such* attract iron, or whether the property of attracting iron is due to some other circumstance peculiar to those particular magnets, we have no ground for a universal conclusion. The meaning must therefore be

that the magnets examined are *as such* the cause of attracting iron. But when this is asserted we have already left the individual instances far behind, and have by abstraction reached our universal law. The major premiss, as well as the syllogism, become therefore superfluous. The doctrine of Uniformity of Nature is present in the reasoning, but only as a belief in the mind, not as a suppressed major premiss.

10. **In what sense is Induction based on the Law of Uniformity?**—That Induction is based on the Law of Uniformity does not mean that the principle of Uniformity is the canon of induction in the same sense in which the "Dictum" is the canon of deductive reasoning. For it does not answer the question, 'How does the mind pass to a universal conclusion from an examination of a few particular cases?' It answers a different question, 'Does the same cause always produce the same effect?' The principle of Uniformity is a *material* principle, not a *formal* law: it belongs to the order of *things*, not to the order of *thought*. The real problem of Induction is to ascertain in what cases we are warranted in asserting that what holds true of the few instances examined holds true of all. The principle of Uniformity offers us a guarantee that our universal judgments, if correctly arrived at, will be verified in fact.

11. Various aspects of the Uniformity of Nature: with which of these is Induction concerned?—Nature is composed not of *one* uniformity, but of many. Philosophy has systematised these into a number of First Principles, the most important of which are :—

(1) The Laws of Thought,
(2) The Mathematical Axioms, and the Axioms of Syllogism,
(3) The Uniformity of Time and Space,
(4) The Persistence of Matter and Energy,
(5) The Law of Causation.

Of these, Induction is chiefly concerned with Causation alone.

12 Uniformity not an Objective but a Subjective Quality.—We must not suppose that what we call laws of nature are actual existences like the woods, or the streams, or the mountains of nature: they are merely expressions of what *we* believe we have uniformly observed. They are products of the mind, formed by processes of abstraction and generalisation. Man does not discover laws pervading through nature: he invents them to describe what he observes. Uniformity is read into Nature by man. It is just as true to say that Nature is infinitely various as to say that she is perfectly uniform. She is at once both and neither.

4th Jan. 87.

EXERCISES.

1. What is the relation between Induction and Deduction? In what sense can they be called two branches of Logic? Which of them is the prior in the order of thought?

2. Define Induction, describing clearly the various characteristics of a true induction.

3. How does the process involved in Induction differ from that of forming a general notion or framing a definition? Illustrate your answer.

4. State, explain, and illustrate the various kinds of induction *improperly* so called. Explain clearly in each case why it is not an induction in the proper sense of the word.

5. "Every induction is a colligation of facts, but every colligation of facts is not an induction." Explain and illustrate this.

6. Explain and illustrate the basis of the "argument from the known to the unknown." Can we do this in all cases? Give reasons.

7. What is meant by the Uniformity of Nature? Is this uniformity prevalent throughout nature? How do you account for the infinite diversity of forms we meet in nature?

8. Archbishop Whately says that the Law of Uniformity is the ultimate major premiss of every inductive syllogism. Explain this view fully, and state whether and how far you agree with this view.

9. Name some of the important aspects of the Uniformity of Nature, and state with which of these Induction is principally concerned.

10. Criticise or justify the following inductions, giving full reasons in each case :—

(*a*) The soul of man is immortal.

(*b*) The circumference of all circles is more than three times the size of the radius.

(*c*) This white powder is neither chalk, nor lime, nor salt ; it must therefore be sugar.

(*d*) All years, except Leap years, have 365 days.

(*e*) James I., Charles I., Charles II., and James II. were all the Stuart Kings of England.

(*f*) All monotheists believe in one god.

(*g*) All scarlet flowers are without fragrance.

(*h*) All horned quadrupeds have cloven feet.

(*i*) All birds lay eggs.

(*j*) Most tropical birds have gaudy plumage.

(*k*) Some Indian horses have a bushy tail.

(*l*) All camels are herbivorous.

(*m*) Monkeys may or may not be classed as quadrupeds.

(*n*) All mammals bring forth their young alive.

(*o*) Agriculture in India depends upon the monsoons.

(*p*) Whenever there is a failure of the rains the result is a famine.

(*q*) All triangles are plane figures.

(*r*) Whenever there is a wet winter the mortality from the plague is high.

(*s*) The tallest trees have always the smallest fruit—witness the peepul, the banyan, the neem, the pine, &c.

(*t*) Whenever the rainfall is heavy the malaria epidemic is severe.

(*u*) The smallest birds are those that sing most sweetly.

(*v*) In all places where the vegetation is dense the rainfall is heavy.

(*w*) All poisonous substances have a bitter taste.

(*x*) Places of pilgrimage become unhealthy during the pilgrim season.

(*y*) A swallow can fly swifter than a dove.

(*z*) All stimulants have a depressing effect on the nervous system.

CHAPTER II.

CAUSATION.

1. Induction is chiefly concerned with Causation.—Of the several aspects of the Uniformity of Nature, that of Causation is the one with which Induction is primarily concerned. The chief object of Inductive Logic is to ascertain the laws of causation that prevail in nature,—that is, to determine the effect of every cause and the cause of all effects. This is so because—

(1) Induction is the process of establishing general truths, and one fact is generally and uniformly true of another only when the two are related to each other as cause and effect;

(2) Events of succession, *i.e.*, events that invariably follow one another, are the most numerous of all phenomena, and the progress of science has continually proved that cases of succession are instances of causation, though the causal connection may in some cases be still hidden;

(3) The Law of Causation is so certain and universal that it serves as an admirable test for verifying universal judgments of all kinds.

Every induction depends on the accurate determination of cause and effect, for it is not possible to lay

down a universal proposition until we have discovered the precise nature of the relation in the case we are dealing with.

2. The Law of Causation.—"The Law of Causation asserts that every event that happens is definitely and uniformly connected with some prior event or events, which happening it happens, and which failing it fails".

—*Bain.*

The Law of Causation asserts two things and denies two things. It asserts—

(1) that every event has a cause; and

(2) that the world is a well-ordered rational system.

It denies—

(1) that events are spontaneous, or occur of themselves; and

(2) that events follow one another irregularly, indiscriminately, or capriciously.

The Law of Causation also implies that the same cause always produces the same effect, but not conversely: the same effect is not always produced by the same cause, for there may be plurality of causes. For example, a severe blow on a man's head will always cause death; but death is not always caused by a blow

on the head. Even where there is a plurality of causes at work, the number of causes is fixed, and the character of each is as definite as if it were the sole cause.* Plurality of causes is, however, more an incident of our imperfect knowledge than a fact in the nature of things; as knowledge extends we find less and less of plurality and more and more of unity.

3. Meaning of 'Phenomenon' in Inductive Logic.—The popular meaning of 'phenomenon' is something out of the ordinary course of Nature, such as an eclipse, or a comet, or a shower of meteors,—particularly such as appeals to the eye. In Logic the term 'phenomenon' means 'anything which presents itself to the senses'. Not only this; but facts of the mind are also spoken of as "mental phenomena". Hence a 'phenomenon' may be defined as *anything which is presented to experience, either external or internal.*

Inductive Logic may thus be said to be chiefly concerned with the causal relation among phenomena.

4. Meaning of 'Antecedent' and 'Consequent'.—Every phenomenon has a set of 'antecedents' and a set of 'consequents'. Those events which

* For a discussion of the doctrine of Plurality of Causes, see para. 19 *infra*.

precede (or accompany) a given phenomenon are called *Antecedents*; while those which follow it are called *Consequents*. Every phenomenon is attended by an innumerable set of antecedents and an innumerable set of consequents, for the number of events happening together or happening in succession, is infinite. It should be borne in mind that the terms 'Antecedent' and 'Consequent' include not only those events that have a bearing upon the given phenomenon, but also those which are apparently unconnected. Those antecedents which have a certain bearing upon the production of a phenomenon are called *Contributory Antecedents*; those that have no bearing are called *Non-contributory Antecedents.*

5 **Meaning of 'Condition'.**—The 'Condition' of a phenomenon is its indispensable antecedent, *i.e.*, that antecedent without which a phenomenon would not be or take place.

There are two kinds of Condition—Positive and Negative. A *Positive Condition* is one that cannot be omitted without frustrating the effect. A *Negative Condition* is one that cannot be introduced without frustrating the effect. A positive condition is so called because its *presence* is needed to produce the effect; a negative condition is so called because its *absence* is needed to produce the effect. For example, a match is lighted and it burns. The positive conditions of the

burning are the sulphur, the phosphorus, &c., on the match, the presence of oxygen in the air, &c.; the negative conditions are the absence of damp on the match box, the absence of a strong wind, &c.

6 Distinction between Cause and Condition.— A 'Cause' is wider than a 'Condition'; it includes all the conditions of an event, both positive and negative. An event may have, and does usually have, many conditions, but only a single cause,—unless there be a plurality of causes, which is highly improbable, if not totally impossible

The failure to distinguish between Cause and Condition has given rise to the popular conception of Cause as that particular condition which happens to be uppermost in the mind at a given moment or in some special connection. Popularly the term 'Cause' is applied sometimes to one and sometimes to another of a large group of antecedents, according to one's special interest or point of view. Suppose a man is killed by a gun. The cause of his death may be variously ascribed (*a*) to the bullet; or (*b*) to a gunshot wound; or (*c*) to nervous shock; or (*d*) to rush of blood into the heart or lungs; or (*e*) to the accidental or deliberate pulling of the trigger; &c. In the popular sense each one of these antecedents may well be spoken of as the "cause" of the man's death; logically, they are only conditions.

7. Distinction between 'Cause' and 'Occasion'.—A 'Cause' is the sum-total of the conditions of an event; an 'Occasion' is that particular circumstance in the series of antecedents which brings the others or the whole cause into operation.

The occasion of an event is often popularly called its cause. For example, a man slips his foot on a ladder and is killed. Popularly, the cause of his death was the fall; logically, the fall was only the occasion, because it was the fall that brought the different conditions of death into operation—by producing concussion of the brain, &c. Many conditions were in this case necessary to bring about the effect (death),—such as the greasy state of the rungs of the ladder, the man's overbalancing himself, the weight of his body, the height from which he fell, the nature of the ground on which he fell, the fragility of the human body, &c. All these are in scientific language called *Collocation of circumstances.*

An *Occasion* may therefore be defined as that prominent and positive incident which completes the collocation of circumstances required for the production of a given event.

8 Distinction between 'Agent' and 'Cause'.—Popular usage often designates as 'cause' what would

more properly be called an 'agent', as when it is said that fire is the "cause" of heat, or a teacher the "cause" of the pupil's knowledge, or the commander of an army the "cause" of a victory. The source of the error here is the popular misapprehension that in nature some things are active, others passive ; the former being called 'Agents', the latter 'Patients'. The distinction between these is merely a verbal one, originating probably from the distinction between the active and the passive voice of verbs in Grammar. In nature all things are alike active ; if agents act upon patients, patients equally react upon agents. The logical definition of 'Cause' includes both the so-called 'agent' and 'patient'.

9. Definition of 'Cause'.—Now that a 'Cause' has been distinguished from (1) a mere antecedent, (2) an antecedent condition, (3) an occasion, and (4) an agent, we may proceed to define it—

"The cause of a phenomenon is the antecedent or concurrence of antecedents on which it is invariably and unconditionally consequent".

—*Mill.*

"The cause is the entire aggregate of conditions or circumstances requisite to the effect".

—*Bain.*

10 Essential Marks of a Cause.—The cause of an event or phenomenon has the following essential characteristics :—

(1) It is *relative* to the effect ;
(2) it is *antecedent* to the effect ;
(3) it is the *invariable* antecedent ;
(4) it is the *unconditional* antecedent ;
(5) it is the *immediate* antecedent ;
(6) it is *quantitatively equal* to the effect.

Each of these essentials will now be explained more fully.

11. The Cause is relative to the Effect.—This means that the cause of an event or phenomenon is an event or phenomenon. Logic has nothing to do with the ultimate, or absolute, or final causes of things ; its sole business is to investigate physical or material causes. The logician selects from the infinite series of connected natural events, that particular event which is *relative* to, or which pertains to the given phenomenon, and is neither too wide nor too narrow for a trained mind to comprehend. For example, we have to inquire the cause of an epidemic of malaria in a certain place. It is not necessary for this purpose to seek the origin of human suffering, or the cause of diseases in general, or even of fevers in particular ; these are not

relative to the given phenomenon: they are too wide.

NOTE.—The phenomenon of which we have to seek the cause must be an *event*; *i.e.*, not a new thing, but a change in something, or in the relative position of things. The following subjects, for example, may be classed as events, and may be regarded as within the range of inquiry:—the phases of the moon, the tides, the freezing and boiling of water, famines, floods, &c. The following subjects are outside the range of logical inquiry:—Why the moon is a planet; why water is a liquid; why heat boils and cold freezes water; why crops do not grow without water; &c. If these questions were made subjects of inquiry it would imply that the moon was not originally a planet, nor water a liquid, &c. The given phenomenon is always an event, *i.e.*, a *change* in the relative position of things.

12. **The Cause is antecedent to the Effect.**—This means that the cause comes first and the effect follows it; hence the effect is called the *consequent*. This view has been objected to by those who maintain that the term 'cause' implies 'effect', so that until an effect occurs there can be no cause. But this amounts to putting the cart before the horse. It is true that the term 'cause' implies an 'effect'—there can be no cause without an effect—but it also implies the *relative futurity* of the effect. The term 'effect' no less implies a 'cause'—there can be no effect without a cause—but it also implies the *relative priority* of the cause. It must not be supposed that cause and effect are

phenomena in any way separate: the course of nature is one continuous series. If, for example, a flood sweeps away a village, the flood itself was caused by excessive rain; the rain came from the clouds; the clouds were formed by moisture sucked up from the sea; and so on. There is no beginning to this, and no break in it. Any of these changes may be taken as an effect, and the cause of it may be enquired into; or it may be taken as a cause, and the effect of it may be pointed out "There is not in Nature", as Carveth Read says, "one set of things called causes and another called effects; but everything is both cause of the future and effect of the past; and whether we consider an event as the one or the other, depends upon the direction of our curiosity or interest".

Though the cause is prior to the effect, this does not mean that the *whole* of the event known as cause should be over before *any part* of the event known as effect begins to take place; the whole cause may not be antecedent to the whole effect; *e.g.*, the causes of the French Revolution continued to work after the Revolution had commenced.

13. The Cause is the Invariable antecedent of the Effect.—This means that a given cause has invariably or always the same effect. The uniformity of

Causation itself implies this. Two important reservations should be borne in mind in this connection :—

(1) *Every* antecedent of an event is not part of its cause. To argue that because one event precedes another therefore it is the cause of that other, would be committing the familiar fallacy known as "*Post hoc, ergo propter hoc*". Every event has an infinite number of antecedents that have no direct bearing upon the production of it. For example, the breaking out of an epidemic in a city may have been immediately preceded by the establishment of a new school, the transfer of a popular official, a fall in the price of silver, and thousands of other noticeable events in that city as well as elsewhere in the world ; but none of these can be said to be the *cause* of the epidemic,—though, of course, all of them are remotely connected with one another, if we take a sufficiently wide view of the working of the world.

(2) Even if two events do invariably occur one after the other, it does not necessarily follow that they are cause and effect ; for they may be co-effects of a common cause. For example, night invariably follows day, but night is not for that reason the cause of day. Thunder always follows lightning, and so does the report of a gun follow the flash ; but they are in each

case co-effects of a common cause. But cases of pure co-existence are very rare : mostly such cases are at bottom cases of causation.

14. The Cause is the Unconditional antecedent of the Effect.—This means that the Cause is that sum of conditions which, without any further condition, is followed by the event in question ; it is the least antecedent that suffices to produce an effect.

It is not enough for the cause to be merely an antecedent, for an event may have an infinite number of antecedents, most of which are connected with it. Nor is it enough that the antecedent should be an *invariable* antecedent, for an invariable antecedent may be only a co-effect, as in the case of the succession of day and night. Both day and night are caused by the Earth's rotation upon its axis. Day is followed by night only if the Earth rotates on its axis. Therefore though Day is the *invariable antecedent* of night, it is not the *cause* of night, because the occurrence of night is *conditional* upon other antecedents, such as the rotation of the Earth, the position of the Sun in relation to the Earth, and the luminosity of the Sun. A cause is the *unconditional* antecedent, *i.e.*, that circumstance which, without being at the same time dependent on any other circumstance, is followed by the given phenomenon ; in other words, it is the sole sufficing circumstance the

presence of which produces the effect, and the absence of which checks it.

15. The Cause is the Immediate antecedent of the Effect.—This means that the cause must not be a *remote* antecedent. Every phenomenon in nature is connected with a large number of other phenomena, the whole forming a series, in which every intermediate link stands to the one immediately preceding, in the relation of effect, and to the one immediately following, in the relation of cause. For example, a flood sweeps a village ; the flood was due to heavy rain, which came from the clouds, which again were formed by the accumulation of moisture sucked up from the sea. These four events form a series, which may be represented graphically as follows :—

(1) Flood
|
(2) Heavy rain
|
(3) Clouds
|
(4) Moisture sucked up from the sea.

The antecedents in this arrangement tend downwards, and the consequents upwards. Suppose we have to inquire into the cause of No. (1) : we must point to No. (2), the antecedent *immediately* preceding

No. (3) is not the cause, nor is No. (4), because they are not immediately preceding antecedents : both of them are "remote" causes.

A "remote cause" cannot properly be the true cause of an event, for it is doubly conditional : first, because it supposes an intervening cause or causes; and secondly, because it only determines in part the conditions that constitute this intervening cause.

At the same time it must be remembered that the term "immediate" is relative in its significance. Wherever phenomena of sense act as causes, our perception of immediacy is subject to the limitations of our sense organs, which are not so keen as to detect all the subtle processes of nature Between an event and what seems to us to be the immediate antecedent, many things may happen which the eye never detects. And where phenomena are treated upon a large scale —such as in Biology, or History, or Economics—"immediacy" must mean long stretches of time and events of remote antecedence. For example, the causes of an event like the Reformation extended far back to the time of Wicliffe.

16. The Cause is Quantitatively Equal to the Effect.—This means that in point of the matter contained and the energy embodied, Cause and Effect are conceived to be equal ; for Causation is scientifically

viewed as the transformation of matter and energy. The quantitative aspect of Causation will become clearer from Bain's analysis of cause into two elements : (1) a moving power, and (2) a collocation of circumstances. When, for example, a spark of fire from the *hookah* of a cooly burns down a petrol godown, the spark is the moving power, and the petrol, a highly inflammable substance, is the collocation. Similarly, when a few grains of arsenic cause a man's death. the arsenic is the moving power, the action of the poison on the human system is the collocation In speaking of the cause of the man's death we should include not only the arsenic, but also the constitution of the human system, the specific action of that drug upon the vital organs, &c.

The following negative proof of the quantitative equality of Cause and Effect is given by Carveth Read :—

" The cause must be equal to the effect ; for if not, it must be either greater or less than the effect, or else sometimes greater and sometimes less. If the first supposition were true, the world and all its operations would continually diminish ; if the second, they would continually increase; while the last supposition is excluded by the principle of uniformity."

17 **In what class of Inquiries can the scientific conception of Cause be applied ?**—The scientific conception of cause can be completely applied in those physical sciences that can avail themselves of exact experiments and mathematical calculation, *e.g.*, Physics, Chemistry, Optics, Dynamics, &c. It may be applied to the inquiry of historical, social, or economic questions after making the proper allowances for counteracting agencies. As a general rule, in cases where experiment and exact calculation are not practicable, Causation has to depend upon its *qualitative* marks alone, *e.g.*, in the case of mental, or moral, or social phenomena. In practical affairs it is often correct to neglect a scientific estimate of all the conditions, and to point to the predominantly important condition alone as the cause of an event. For example, the depreciation of the value of silver may be ascribed with equal correctness, (1) to the over-production of silver, or (2) to a slackening in the demand for silver, or (3) to the adoption of a gold standard by most countries of the world.

18. **Common Fallacies in Causal Inquiries.**—From what has been said in the foregoing paragraphs it must be clear that the nature of Cause cannot be designated by any single phrase. Causation is a most complex problem, in the solution of which there are more pitfalls than in any other intellectual process. It

has therefore seemed advisable to bring together the commonest cases of error in the determination of cause and effect. A bare list is, however, all that can be given here: the full treatment of such errors must be postponed until we come to Inductive Fallacies.

The commonest fallacies of Causation are:—

(1) Neglect to take account of the whole cause, as when a single condition is mistaken for the whole cause. (See Para. 6, above).

(2) Mistaking the occasion for the casue. (Para. 7).

(3) Mistaking an agent or instrument for the cause. (Para. 8).

(4) Assigning absolute or ontological causes instead of physical or material ones. (Para. 11).

(5) Confusion between cause and effect, owing to their interaction. (Para. 12).

(6) Mistaking a variable or wrong antecedent for the cause. (Para. 13).

(7) Mistaking a pure co-existence or sequence for the cause. (Para. 13).

(8) Mistaking a conditional antecedent for the cause. (Para. 14).

(9) Assigning a cause that is too remote. (Para. 15).

(10) Neglect to take account of the whole effect. (Para. 16).

19. Plurality of Causes.—"Plurality of Causes" is a doctrine which has been the battle-ground of logicians for ages, and the contest is still undecided. Those who advocate the doctrine of Plurality of Causes mean by it, not that a great many causes are sometimes requisite to the production of an event, but that the same event may be produced at different times by different causes. For example, death may be due to disease, or senile decay, or accident, or violence, or starvation. Loss of health may be caused by bad climate, or bad food, or bad sanitation, or inherited diseases.

Criticism of the Doctrine.—The doctrine is only apparently sound. There can be no such thing as plurality of causes. We think of a possible plurality only because we are unable to perceive the real difference among events that resemble one another in the gross, or because we neglect to take account of the whole effect. Let us examine the illustration given by the advocates of Plurality in support of their doctrine. They say that death may be due to different causes in different cases. But close examination will reveal the fact that death by one cause, say starvation, is actually different from death by another cause, say accident. In each form of death the effect is modified according to the nature of the cause. In one it may

be due to heart failure; in another, to gradual cessation of the vital functions owing to the impoverishment of the blood supply; in a third, it may be due to concussion of the brain; in a fourth case, it may be due to cramp in the stomach; and so on. Scientifically, therefore, plurality cannot be maintained if we are as exhaustive in our enumeration of the constituent elements in the total effect as we are in those of the cause. But the mistake we make is that we specify the cause in detail, but describe the effect only in general words; and thus come to perceive plurality where none exists.

Nevertheless, as it is beyond the power of men to know events minutely, it is necessary, in practical affairs, especially those that deal with human life, to acknowledge a possible plurality of causes. This, however, is not a principle of logic, but a rule of common-sense. The omission to acknowledge this leads in many cases not only to possible error but to positive mischief. As examples of rash generalisations made in heedless disregard of plurality, we may mention the following that have unfortunately gained some currency in India:—

'That export of food grains is the cause of the rise in the prices of commodities';

'That the Settlement of the land revenue is the cause of famines'.

Such vast subjects of inquiry as the rise in prices or famines cannot obviously be dismissed so summarily.

20. Intermixture of Effects.—When several causes act at once and their effects are blended together, it is called "Intermixture of Effects". Intermixture of effects is far more common than plurality of causes. In abstract inquiries, such as those of science and mathematics, we may confine our attention to only one cause; for example, we may say that the movement of a cricket ball is caused by the stroke of the bat, although as a matter of fact, the strength of the player, the make of the bat, the condition of the cricket field, &c., have each something to do with the effect. But in concrete cases, such as the problems of everyday life, we cannot usually assign a single cause for a single event, or a single effect to a single cause. All instances of causation are really cases of interference of causes and intermixture of effects.

Intermixture of Effects takes place in two ways:—

(1) as *mechanical composition* of causes; *e.g.*, two horses pulling the same carriage;

(2) as *chemical combination* of causes; *e.g.*, hydrogen and oxygen combining to produce water.

In the former, the separate effects of all the causes continue to be produced, but are merged in one another, and disappear in one result. In the latter, the separate effects cease entirely, and are succeeded by phenomena altogether different and governed by different laws.

21. **Tendency.**—When a cause consists of two or more conditions, the effect of any one of them, if it operated alone, is called its *Tendency*. A tendency is said to be *counteracted* when it is prevented from manifesting itself, either wholly or partly, by the operation of a different condition working in a different direction. For example, a feather let fall from the hand has a tendency to drop down on the ground. This tendency is *partially* counteracted by the resistance of the air; and it may be *wholly* counteracted by a wind. The counteraction may be entirely removed by the feather being dropped in a vacuum. This removal of the counteraction is called the *Elimination* of the counteracting circumstances, and this elimination is the essential process in the study of Causation, just as Causation is the essential subject in the study of Induction.

EXERCISES.

1. Why is Induction chiefly concerned with Causation ?

2. Give as clear a statement as you can of the Law of Causation.

3. Distinguish between antecedent and consequent. Do they always go in pairs ? Can an antecedent have only one consequent, or a consequent only one antecedent ? Give reasons.

4. What do you consider to be the difference between *Cause* and *Condition* ? Give examples.

5. Distinguish between *Cause* and *Occasion*, and between *Cause* and *Agent*.

6. Draw a careful contrast between the popular view and the scientific view of Causation.

7. What is meant by the cause being *relative* to the effect ?

8. What do you think to be the commonest fallacy in Causation ? Give one or two examples of it.

9. "The cause is the unconditional antecedent of the effect." How far is this a correct definition of *Cause* ?

10. The cause is said to "be the immediate antecedent of the effect". Show that the word "immediate" is very elastic in this phrase.

11. Distinguish between the *qualitative* and *quantitative* aspect of Causation. How would you prove that cause and effect are quantitatively equal ? Is there any truth in the following saying—

'What great events from trivial causes spring !'

12. Is it possible to carry the scientific conception of Causation into all branches of inquiry ? Give reasons and illustrations.

13. Discuss the doctrine of Plurality of Causes, stating your own view of the question.

14. What is meant by the Intermixture of Effects ? In what ways does it take place ? Give examples.

15. What is meant by a Tendency ? When is a tendency said to be counteracted ? Give examples.

16. What is Elimination ? What is its importance in Induction ?

17. Examine the following instances of Causation, giving full reasons in each case :—

(*a*) A workman carrying a load of bricks on his head, falls from a scaffolding and dies. His death is reported as " due to an accident".

(*b*) A man in the street is run over by an Ekka and killed : the Ekka is said to be the cause of his death.

(*c*) A young Hindu listens to the preaching of a Missionary, and is converted to Christianity : the preaching is said to be the cause of his conversion.

(*d*) A man gets wet in the rain one day in July, and has an attack of fever the next day. Shortly after he recovers and enjoys good health for a month or so. He then has a relapse. One day during this second attack of fever, the doctors put an ice compress on his head, and this brings on an ague. This ague develops into pneumonia, and the pneumonia gets worse and worse until both lungs are affected. Ultimately meningites sets in, and the man dies after a protracted illness in December of the same year. How far may the wetting be spoken of as the cause of his death ?

(*e*) Luther's burning of the Pope's Bull is said to be the cause of the Reformation.

(*f*) A student falls ill during an examination and fails: his illness is said to be the cause of his failure.

(*g*) A student engages a private tutor and passes his examination : the tutor is said to be the cause of his success.

(*h*) There is an epidemic of cholera in a city and the doctors attribute it to impure drinking water.

(*i*) A Deputy Collector is transferred from Allahabad to Gorakhpore, and shortly after loses his health : his transfer is said to be the cause of his ill-health.

(*j*) A man rents a new house and soon after occupying it, falls ill : his neighbours tell him that the house is haunted by a ghost, and that this ghost must be the cause of his illness.

(*k*) A man suddenly wins a fortune by lottery : his good luck is said to be the cause of his becoming suddenly rich.

(*l*) There is an eclipse of the moon, and the inhabitants of a village attribute it to the demon Rahu's swallowing the moon.

(*m*) The fertility of the soil is everywhere attributed to Nature.

(*n*) Fire burns, because it is said the god Agni has imparted to it the quality of combustibility.

(*o*) What is the cause of the universe? God.

(*p*) The cause of man's being a rational animal is that he has been made after his Maker's image.

(*q*) *A* and *B* had a quarrel, and *B* meditates revenge and ultimately succeeds in murdering *A*. Revenge is said to be the cause of *A*'s death.

(*r*) A man, while crossing a river in a boat, is overtaken by a sudden squall and drowned. What do you consider to be the cause of the man's death ?

(*s*) A man's evil deeds are said to be caused by an Evil Spirit.

(*t*) The downfall of Napoleon is said to have been due to his Russian expedition.

CHAPTER III.

OBSERVATION AND EXPERIMENT.

1. Function of Observation and Experiment in Inductive Logic.—Observation and Experiment are the *material* ground of Induction; the principle of Causation, the *formal* ground. This means that the Law of Causation affords a means of testing *formally* (*i.e.* by rules) the *materials* (*i.e.* concrete facts) supplied by Observation and Experiment, in order to determine whether those facts are sufficient to establish a causal connection between phenomena. The chief aim of Induction is to determine relations of cause and effect, *i.e.*, to establish uniformities or laws. This cannot be done unless we reduce the phenomena of nature to order and system. For Nature, as she appears to us, presents at every moment a "chaos followed by another chaos"; it is only by careful observation that we can detect regularity and law beneath their disorderly appearance. Observation and Experiment are an essential means to the discovery of the orderly course of nature: this again is essential to the establishment of causal connections between phenomena; and the establishment of causal connections is the chief business of Inductive Logic.

2. Nature of Observation.—Observation is the application of our faculties to the accurate determina-

tion of natural phenomena. The faculties directly employed are our external senses—sight, sound, smell, taste and touch, but these can only act in conjunction with intelligence. "It is the intelligence of man that is the true observer, and the senses are but instruments of the observant mind".

From this follows three facts with regard to the nature of observation :—

(1) Observation is always *selective* ; the mind fixes its attention on some one point from among the numerous aspects of outward nature.

(2) It is made in order to furnish a reply to some question which has proposed itself to our mind, and to see whether some particular answer will prove satisfactory or not. In other words, observation is generally made in the light of some *hypothesis.*

(3) Observation implies some degree of *previous knowledge* of the phenomenon observed. This previous knowledge acts as a guide in selecting the features of the phenomenon to be examined, and leaving out of consideration those that are immaterial to the purpose in view.

3. Conditions of Observation.—It is impossible to lay down any hard and fast rules for conducting observations. Each one observes in the manner that

suits him best, with such artificial aids and appliances as may be necessary for the particular phenomena under investigation. The extent and minuteness of the observation also vary with the nature of the phenomena to be observed.

There are, however, certain general conditions to be fulfilled by observers, before they begin their observations. These conditions are (1) intellectual, (2) physical, and (3) moral.

(1) The chief *intellectual* condition is the spirit of inquiry—the desire to know the causes of things, which is the origin of science and philosophy.

(2) The chief *physical* condition is that the senses employed should be sound.

(3) The chief *moral* condition is impartiality. This condition is the one most difficult to fulfil, for every one has opinions and prejudices of his own, and desires that his beliefs may be confirmed. The successful observer must therefore have that candour and openness of mind which will enable him to register, with perfect fairness, facts both for and against his own peculiar views.

4. Nature of Experiment.—Experiment is defined by Fowler as the work of placing phenomena under peculiarly favorable circumstances as a preliminary to observation. Appeal to experiment is neces-

sary whenever simple observation alone will not reveal all the essential conditions of a phenomenon. Its object is to eliminate all conditions which are not specially operative in the particular case under investigation.

5. Relation of Observation and Experiment.—Observation and Experiment are kindred processes :

(1) Both are branches of experience, only that Observation is passive, Experiment, active. In Observation we watch phenomena as they are presented to us by nature; in Experiment, we watch phenomena under conditions imposed by ourselves and artificially simplified,—because the phenomena, as they occur in nature, are extremely complex.

(2) Observation may be carried on without set purpose; Experiment necessarily requires an hypothesis, for to experiment is to question Nature, and our question must take some clearly defined form.

The two processes are essentially alike, and differ rather in degree than in kind. The object of both is to furnish us with accurate and trustworthy facts on which we can base our reasoning.

6. Negative Experiments.—A *negative experiment* is one which is designed to show not only that a particular antecedent always involves a particular consequent, but also that this consequent never occurs except

when this particular antecedent has preceded it. Joyce quotes in illustration the series of experiments which were undertaken in regard to the Sleeping-sickness in Uganda. Careful observation first established that the disease was due to a certain microbe communicated to the blood of a patient by the bite of the tsetse fly. But another series of experiments showed that even where all the other conditions accompanying the disease were present, yet if this microbe was absent, the disease never appeared. The latter series constituted what are called *Negative Experiments.*

7. Natural Experiments.—A *natural experiment* is one that is performed as it were by the hand of Nature. It is an event in which the processes of nature themselves produce special and determinate conditions, under which the phenomenon in question may be observed. An eclipse of the sun or moon is a natural experiment, because it enables us to make certain astronomical observations under special conditions.

8. Advantages of Experiment over Observation.—In those cases where experiment is practicable, it possesses many advantages over observation :—

(1) In experiment we can study a phenomenon after separating the relevant from the irrelevant circumstances ; in observation we rarely find a phenomenon completely isolated.

(2) In experiment we can vary the circumstances, in order to observe a phenomenon under different conditions, and in order to separate the essential from the unessential conditions; whereas in observation we have to depend upon Nature to afford us a suitable diversity of instances.

(3) In experiment we can reproduce a phenomenon as often as we like and thus minimise chances of error; whereas in observation we have to look to Nature for the recurrence of a phenomenon.

(4) Experiment is more precise than observation, because in experiment we can place a phenomenon in the midst of the exact set of circumstances which we require.

(5) Experiment is more subtle than observation, because in it we can detect minute changes which might escape mere observation.

(6) Experiment is more expeditious than observation, because it can give us in a short time results which Nature might yield in many years or might never yield at all.

9. Advantages of Observation over Experiment.—(1) Observation can be freely employed in branches of knowledge where experiment is impossible. For example, observation is our only resource in the

study of the heavenly bodies, the ebb and flow of the tides, the strata of the earth, the structure of the body, the function of the various organs, &c.; no experiment is possible in any of these subjects.

(2) Observation can be employed in the investigation of causes as well as of effects, whereas experiment is limited only to the search of effects. Experiment can enable a cause to produce its effect, but cannot make an effect reproduce its cause; so that the chief limitation of experiment is that a large number of Nature's processes cannot be imitated.

10. Observation and Experiment are supplementary processes.—Observation and Experiment are both necessary in inductive inquiries. They are the two chief means by which the truth of theories about reality can be ascertained and established. They also aid us in analysing the complex phenomena presented to us in nature, and in examining them in detail. "They form the foundation of the temple of knowledge".

There is no radical difference between the two processes: the one runs into the other. The most passive observation involves some degree of experimentation, since the observer has to put himself in a frame of mind and to place himself in a position favourable to his undertaking. In the same way, the most elaborately

artificial experiment cannot proceed without observation, since we have to watch the result at every step of the process. But while observation is indispensable in every inductive inquiry, it can assist only in establishing sequences and co-existences—*i.e.*, in affirming that such and such things follow each other or accompany each other. Mere observation cannot *prove* causation, —hence the great importance of experiment in all scientific research.

EXERCISES.

1. What are the functions of observation and experiment in inductive inquiries ?

2. Specify the exact nature of Observation, and name the conditions that determine accurate observation.

3. Define Experiment, and describe its function in Logic. What do you understand by Negative and by Natural Experiments ? Give examples of each.

4. What is the relation of Observation and Experiment ? Show that these processes are supplementary to each other.

5. Point out the comparative advantages of observation and experiment as methods of scientific investigation.

6. Observation and experiment " form the foundation of the temple of knowledge ". Explain this.

CHAPTER IV.

CLASSIFICATION AND NOMENCLATURE.

1. Place of Classification in Inductive Logic.—Classification is a most important aid in induction: indeed, both are based on the same principle. The essential unity of Nature, which forms the basis of all inductive inference, lies also at the root of all classification. The very idea of species under a genus implies that different classes of things partake in the same general nature, and that they are distinguished from each other by essential and regular differences,—in other words, that attributes always co-exist in a fixed and definite way. Without classification any knowledge of things would be impossible. Classification is an essential step in the explanation of nature, and the explanation of nature by means of Causation is the essence of Induction.

2. Definition of Classification.—"Classification, in its widest sense, is a mental grouping of facts or phenomena according to their resemblances and differences, so as best to serve some purpose".

—*Carveth Read.*

3. Nature of Classification.—The nature of Classification will appear from a close analysis of the above definition.

(1) A Classification is a *mental grouping* of facts or phenomena. Physical grouping of objects, such as that in a museum, does not amount to classification : it is only an arrangement *representing* a classification. The classification itself may extend to objects which have never been seen, such as extinct animals.

(2) The basis of classification is *resemblances and differences* among things ; that is, those things that closely resemble one another are put into one class, while those that widely differ from one another are put into other classes. The greater the difference among things the wider apart are their classes.

(3) The classification *serves some purpose* in view. The purpose may be :

(*a*) special or practical, *e.g.*, gardening is a special or practical purpose in the classification of plants, hunting, in that of animals ;

(*b*) general or scientific, *i.e.*, for the sake of knowledge only ; *e.g.*, the classifications of Botany and Zoology aim only at the progress of these sciences.

4 In what Sciences is Classification of importance ?—The sciences may be broadly divided into (1) those dealing with the stable or fixed forms of nature ; and (2) those dealing with the active or moving

forms of nature. To the former group belong such sciences as Botany and Zoology ; to the latter group belong such sciences as Physics and Chemistry. The former group relies chiefly on observation, the latter on experiment. Classification is an important aid to the study of the former group of sciences, which are for that reason sometimes called the "Classificatory Sciences".

5. Classification and Development of Language. —Classification as a mental process may, in a rude form, be called an instinctive quality, in that even animals display this power in some degree, as when a cat does not confound a dog with one of her own species. But in the case of human beings, Classification has originated with the development of language, and the progress of the one has kept pace with the progress of the other. As new things have been discovered or made from time to time, new names have been coined to designate them. The use of general names implies classification, *i.e.*, the recognition of classes of things corresponding to them, which form their denotation, and whose resembling qualities form their connotation. The use of abstract names also implies classification, because it shows that the objects classed have been analysed, and their resembling qualities have been recognised amidst many differences.

6 Uses of Classification.—Classification is a most useful scientific process :—

(1) It conduces to a better understanding of the facts of nature ; for clear understanding consists chiefly in perceiving and comprehending the resemblances and differences of things.

(2) It aids the memory—for thinking of things arranged in classes facilitates our remembering them.

(3) It gives greater fertility and flexibility of thought, for by arranging and rearranging things we can discover new connections among them, and avoid that belief in finality which is fatal to the progress of human thought.

(4) It enables us to systematise our knowledge.

(5) It assists in the discovery of new laws.

7. Comparison between Classification and Division. The relation between Classification and Division is the same as that between Induction and Deduction. The two processes aid and supplement each other, though there are striking points of difference between them :—

In Classification we begin with particular things and arrange them into groups, according to their likeness, forming wider and wider groups as we advance ; in Division we begin with a large class, and

split it into smaller and smaller groups, until we come to individuals, after which no further division is possible. Thus, in Classification we proceed from the less general to the more general, from the parts to the whole ; in Division we proceed from the more general to the less general, from the whole to the parts.

(2) In Division the terms 'Genus' and 'Species' are entirely relative to one another, and have no fixed positions in a series, so that the same group may stand as genus in one connection, and as species in another ; in Classification the term 'Species' is given to classes regarded as lowest in the scale, and the term 'Genus', to classes one step above,—classes higher than the genera being called 'Tribe', 'Order', 'Sub-kingdom', and 'Kingdom', while those lower than the species being called 'Varieties'.

(3) Classification is a *material* process, involving observation and comparison ; Division is a *formal* process, conducted merely in accordance with rules, on the basis of the knowledge already acquired.

8. Comparison between Classification and Explanation. Classification is closely analogous to Explanation :—

(1) Explanation consists in the exposition of the laws or causes of the changes that take place in

nature; Classification consists in the discovery of resemblances in the things themselves that undergo change.

(2) In both there is the search for similarity or resemblance. The determination of cause and effect, which is the main object of Explanation, rests on the accumulation of cases of agreement; Classification likewise proceeds on the basis of resemblance among things.

(3) Explanation analyses Nature in her *dynamic* aspects—*i.e.* the moving activities, the operating forces of nature; Classification studies Nature in her *static* aspects,—*i.e.* those forms that undergo little or no ostensible changes*.

(4) In both processes there is a satisfaction of our intellectual curiosity. There is a sense of relief both when the cause of an event is pointed out to us (Explanation), and when an object is put in its proper place in a system of classes (Classification).

(5) Both tend to rationalise the memory and to organise the mind in conformity with Nature. We remember a thing better and more sensibly and naturally when it is explained to us or classified for us.

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* See Para. 4 *ante*.

9. Kinds of Classification.—There are two kinds of Classification commonly recognised:—

(1) *Artificial Classification*, which is based on some attribute selected by us for our own convenience;

(2) *Natural Classification*, which is based on natural affinity.

These two kinds of Classification will be treated at greater length in the following paragraphs.

10. Artificial Classification.—In artificial classification any attribute at all may be taken to serve as a basis of arranging things into groups, provided:

(1) it is common to the whole group of objects to be classified; and

(2) it is sufficiently distinct to enable us to assign each individual to one and only one group,—*i.e.*, to avoid what is called a Cross Division.

Hence the same group of objects may be differently classified by different men. For example, a collection of pictures may be classified in several ways:—

(*a*) according to the events represented,

(*b*) according to the style of the art,

(*c*) according to the artists whose works they are,

(*d*) according to their price.

11 **Two Varieties of Artificial Classification.**—There are two varieties of artificial classification :—

(1) that in which the objects to be classified are limited in number ;

(2) that in which they are unlimited.

In the former we affix an artificial mark to each member of the class, as is done, for example, in classifying the books belonging to a particular library, or the paintings of a certain picture gallery, or the army or navy of a country, or the Hackney carriages and Ekkas of a particular town, &c. In the latter, we rely on some natural characteristic, and yet the classification is artificial; *e.g.*, the famous Linnæan system of Botany, in which the various plants are arranged according to the number of stamens and pistils they possess, regardless of their natural affinities. The arrangement of names in a biographical dictionary is another example of artificial classification, because in it men of different races and ages—some famous for their virtues, other for their crimes—are arranged into twenty-six groups, according to the place which the first letter of their name holds in the alphabet.

12 **Defects of Artificial Classification.**—Artificial classification, however useful it may be in special

cases, cannot prove entirely satisfactory, for the following reasons :—

(1) It omits many things merely because they are not useful or conspicuous ; natural classification omits nothing,—it includes even things that have ceased to exist.

(2) Things are examined very superficially in artificial classification ; in natural classification their real nature is carefully examined.

(3) Things are often wrongly classed, as when a whale is classed as a fish, or a bat as a bird.

(4) It is neither comprehensive, nor discriminative nor systematically coherent.

13. Advantages of Artificial Classification.—Artificial classification is convenient whenever the perplexities of the natural system of classification are very great. In any case an artificial classification is better than chaos. It at least enables us to assign a definite place to each member of a group in virtue of distinctive and easily recognisable marks.

14. Natural Classification.—Natural Classification consists in placing together in groups things that possess in common the greatest number of important attributes—'important attributes' being those that

exercise a determining influence on the greatest number of characteristics, or those that contribute to render the things like one another and unlike other things, *i.e.*, those which give to the class the most marked individuality.

Classes formed on this basis of natural affinity are called "*natural groups*".

15. Difficulties of Natural Classification.—In natural classification it is not enough to consider the external appearance of things, but also their internal structure, and the functions of every limb and part. This can be accomplished only after immense research. The order of nature is too complex and too various to be easily comprehended. Besides this, there are other difficulties to be encountered in the work of natural classification :—

(1) In co-ordinate classes the same organ is often found to possess very different values.

(2) The same quality is of different value at different stages of the animal's existence.

(3) The same animals may possess organs which are characteristic of different species.

16. Rules of Classification.—The following are the rules usually given for the work of natural classification :—

(1) All groups should be so constituted as to

differ from one another by as many attributes as possible.

(2) The higher the group the more important should be the attributes by which it is constituted.

(3) The orders should be graduated, so that the groups with most affinity should be nearest together.

17. Tests of Classification.—The rules for testing a Classification are the same as those for Division :—

(1) Each sub-class should comprise less than the class.

(2) The sub-classes taken together should be equal to the class.

(3) The sub-classes must be mutually exclusive.

(4) No sub-class must include anything that is not comprised in the class.

18. The controversy as to whether there are Natural Species.—Some logicians maintain that the members of the animal and vegetable kingdoms are distributed in types possessing certain broad resemblances, and a multitude of the most detailed characteristics in common. These characteristic resemblances manifest themselves through the whole of the organism,—in structure, in process of development, in reproduction,—and they are repeated generation after generation without change.

The Evolutionists, however, deny the existence of separate species. According to the theory of Evolution, animal and plant life is susceptible of indefinite variation, and in the struggle for existence, the weaker forms have perished and the stronger have survived. The characteristics which mark the different kinds of birds and beasts, are not due to the impress of different types : they are merely the record of this long struggle for existence. They say there is no such thing as type. Class merges into class, and there are no abrupt transitions in the scale of living beings.

The whole controversy disappears if we but consider the fact that those who maintain the existence of distinct species are in no way concerned with the theory of Evolution, which only states the *manner* in which they originated.

19. Are Natural Groups determined by Type or by Definition ?—Another vexed question in connection with Classification is whether natural groups or species are determined by Type or by Definition.

Whewell's view is that Classification should be based on Type. A *type* means a perfect specimen of any class, a species of a genus which is considered as eminently possessing the character of that class. All the species which have a greater affinity with this type than with any other, form the genus, and are arranged

about it, deviating from it in various directions and in various degrees.

Mill objects to this theory and maintains that Classification should be based on Definition. The problem of classification is to find a few definite important attributes, and then to arrange the objects according as they display those attributes in greater or less degree. The type is useful, not as furnishing a basis of classification, but as *illustrating* the definition of a class. It is definition that determines the natural groups ; the type only *suggests* them. If classification were framed not by definition, but by type, no general proposition of any kind could be asserted about a class ; whereas classifications are chiefly valuable in so far as in them we attain to general truths and laws of nature.

20. Classification by Series.—Serial Classification is that in which things are not only arranged into groups, but the groups are also arranged in a series, according to the degree in which they exhibit a particular quality—beginning with those that exhibit it most, and terminating with those that exhibit it least.

Serial Classification is employed in those cases where there is a gradual progress or development, and where the quality developed has a commanding importance.

This mode of classification is supplementary to Natural Classification.

21 Classification and Nomenclature.—'Nomenclature' means a system of the names of all classes of objects adapted to the use of each science. As classification progresses, new classes are discovered, old groups are reconstituted, and the whole series re-arranged ; and new names are needed in each of these processes. Hence nomenclature must keep pace with the progress of classification.

22. The Relation of Language to Thought.—Language serves three important purposes :—

(1) It serves as a means of recording our thoughts ;

(2) it helps us in communicating our thoughts to others ;

(3) it enables us to form general or abstract ideas.

Language is practically essential to thought. It is true that we can often think of persons and objects with the aid of images alone ; we may also be able to form judgments and inferences in particular cases ; but for general notions, judgments, and inferences we need something more than the few images we can form of men or things from observation or from pictures.

Even in those cases where we may possess generic images, such as of 'horse' or 'dog,' these are useless for precise thought :

(*a*) because the generic image will not correspond with the general appearance of the thing, unless we have had experience of all varieties ; and

(*b*) because what we want for general thought is not a generic image, however correct it may be, but a general representation of their important characters.

For purposes of thought we require a *symbol*, connected with the general character of a thing, or quality, or process, as scientifically determined ; and such symbols are provided by language.

23. Difference between Popular Language and Scientific Language.—The words used in popular speech fall into the same classes as those of scientific language; they stand for things, and parts, qualities, or activities of things ; but they are far less precise in their signification. As long as popular thought continues to be vague and undefined, the language of ordinary speech must remain vague and undefined also. This vagueness of popular language is sometimes of great use :

(1) it gives elasticity and suggestiveness to common terms, and it is on these qualities that the effect of poetry and eloquence chiefly depends ;

(2) even in reasoning it is a mistake to aim at an unattainable precision ; it is better to indicate our meaning approximately, or as we feel about it, than to convey a false meaning by attempting to be precise.

24. Requisites of Scientific Language.—If we want to think accurately, the language in which our thoughts are expressed must be accurate also. The chief requisites of scientific language are :—

(1) that there should be a name to express every important meaning. This implies :

(*a*) that there should be a *Nomenclature*, or system of the names of all classes of objects, adapted to the use of each science. Thus, in Geology, there are names for classes of rocks and strata ; in Chemistry, for the elements and their compounds; in Zoology and Botany, for the classes and sub-classes of animals and plants ; &c.

(*b*) that there should be a *Terminology*, or system of terms to describe and define the things that constitute the classes designated by the nomenclature.

(2) That there should be a fixed and precise meaning for every name. This means that as far as possible there should be a *Definition* for every scientific name.

25. Difference between Terminology and Nomenclature.—(1) 'Terminology' means a 'system of terms'. It includes names of things as well as attributes, and aims at describing and explaining their actions. 'Nomenclature' means a 'system of names'. It includes only names of the *classes* of objects with which a science deals. Nomenclature is thus a part of Terminology.

(2) Terminology may be said to be *descriptive* in its aim ; Nomenclature, *classificatory*.

It is difficult to say which of the two comes first in the evolution of a science, but the two together are needed to make up scientific language. It is difficult also to draw a clear line of demarcation between them, since the one runs into the other. The same set of terms may form part of the nomenclature of one science, and of the terminology of another. For example, the terms *muscle*, *bone*, *limb*, &c., belong to the nomenclature of Anatomy, but to the terminology of Zoology.

26. Essentials of a good Terminology.—A good

terminology should be as comprehensive, as descriptive, as detailed as possible. It should provide for :

(1) Names for every integral part of an object ; *e.g.*, head, heart, nerve, vein, &c. ;

(2) Names for every metaphysical part of an object, *i.e.*, for every abstract quality of it, and for their degrees and modes ; *e.g.*, extension, figure, solidity, weight ; rough, smooth ; red, blue, green, &c.

(3) Names for describing processes and activities ; *i.e.* deduction, addition, causation, tendency, gravitation, &c.

27. Essentials of a good Nomenclature.—Any system of names will not do for a science : the names must possess the following qualities :—

(1) They should be systematically significant, *i.e.*, they should not only bear a meaning, but the meaning should be derived according to rule, not shaped by caprice.

(2) They should be elegant, not clumsy.

(3) They ought to be efficient, *i.e.*, convey the most meaning with the least effort. For example, in Botany and Zoology each species has a composite name, which includes that of the genus to which it belongs. In Chemistry again the nomenclature is

extremely efficient, the names of the simpler compounds being formed by combining the names of the elements that enter into them.

(4) The names should possess all degress of generality, *e.g.*, species, genus, section, order, division, sub-class, class, sub-kingdom, kingdom.

28. Definition.—The second important requisite of scientific language is that there should be a fixed and precise meaning for every name ; that is to say, it must provide for accurate definitions of scientific terms. Definition may be called the foundation of a good terminology : it is the first stage of accuracy of thought, and marks the beginning also of accuracy of language.

29. Definition compared with Description.—To define a name is to give a precise statement of its meaning or connotation. For ordinary purposes it may be a sufficient definition to give a rough list of the qualities of an object, such as are enough to identify the thing ; for example, a lion may be ordinarily defined as "a huge tawny beast of prey, with a tufted tail". This is not a scientific definition, but a popular *Description.* A Description, therefore, differs from a Definition in that it seeks to distinguish a thing from other things by an enumeration of its accidents ; whereas

a Definition does so by mentioning the differentia, or the quality or qualities which distinguish it from other things of the same class.

"Definition is the analysis of a concept; Description is the setting forth of the mental picture which accompanies a concept.

Definition is an appeal to thought; Description is an appeal to imagination."

—*Stock.*

30. Scientific Definition distinguished from Logical Definition.—The Definition with which we have to deal in Inductive Logic is not the same with which we were concerned in Deductive Logic. Inductive Definition is *material*, Deductive Definition, *formal*. Inductive or Scientific Definition is essentially a process of generalisation, involving investigation into the properties of things, with a view to ascertaining the important common qualities which form the connotation of the name. Deductive or Logical Definition consists in assigning a thing to the genus to which it belongs, and mentioning the specific difference or the distinction between the thing and others of the same class; it does not tell us how we can obtain either the character of the genus or the differential characters of the species.

31. Two modes of framing Scientific Definitions.—There are two modes of framing scientific definitions :—

(1) The *Positive Method*, of which the rule is —'Assemble for comparison the particulars coming under the notion to be defined.'

(2) The *Negative Method*, of which the rule is —'Assemble for comparison the particulars of the opposite or contrasting notion'.

The term "*particulars*" means not every individual instance, but *representative* instances, sufficient to include extreme cases as well as normal ones.

Suppose the botanist has to define a species of plant by the positive method : how does he proceed ? He first collects recognised examples of the species, including the widest extremes admitted into it. He then compares the several specimens, noting their resemblances; until he finds what qualities pervade the whole ; these he expresses in suitable language, which is henceforth the definition of the species.

The utility of the negative method is immeasurable ; for it is impossible for anything to be precisely defined unless its opposite is known. It is impossible, says Bain, to place the human mind in a more favorable position for comprehending a generality, than by

laying out to the view two arrays of particulars—the one representing the given notion, the other its negative.

32. Relation of Definition to Classification.—The relation between Definition and Classification is exceedingly intimate :—

(1) Classification implies Definition. Classification consists in distributing things into groups according to their points of likeness and difference ; in doing so we recognise the common qualities or points of likeness ; and to enumerate these is to define the name of the class.

(2) Classification and Definition both depend upon observation and induction.

(3) Definitions are relative to one another in the same way as the classes represented in a classification are related to one another.

EXERCISES.

1. What is Classification, and what is its function in Inductive Logic ?

2. Show the relation of Classification to the development of language.

3. Enumerate the uses of Classification.

4. Distinguish between Classification and Division, and between Classification and Explanation.

5. What is Artificial Classification? Point out its advantages and disadvantages. Compare it with Natural Classification.

6. What are the difficulties of natural classification, and what rules have been made to obviate these difficulties?

7. Discuss the question whether there are in nature well-defined types or species. Of what importance is this controversy in the subject of Classification?

8. Distinguish between Classification by type and Classification by series.

9. Are natural groups determined by type or by definition?

10. What relation does Nomenclature bear to Classification?

11. Contrast between Popular and Scientific Language. Name the two requisites of scientific language.

12. Describe exactly the relation of Language to Thought.

13. What is the difference between Terminology and Nomenclature? Describe fully the essentials of a good Terminology and a good Nomenclature.

14. In what respects does Definition differ from Description?

15. Point out the difference between Inductive and Deductive Definition.

16. Show the relation of Definition to Classification.

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CHAPTER V.

HYPOTHESIS.

1. Place of Hypothesis in Inductive Logic.—Hypothesis marks the first stage of induction. In the process of arriving at general laws, the investigator has often need to start from a supposition or conjecture which appears likely to explain the fact. This supposition or conjecture is called an *Hypothesis*, and if it affords a satisfactory explanation of all the observed facts, and is subsequently verified by experience, it passes into a law.

The value of Hypothesis in inductive inquiries is a matter of dispute. Whewell maintains that induction consists in framing hypothesis after hypothesis, until one is found which fits the phenomenon under investigation exactly; and then the conclusion drawn is regarded as a valid induction. Mill does not accept this view. According to him, induction is proof, and an hypothesis, being a mere supposition on insufficient evidence, is at best a defective kind of proof. Mill maintains that an hypothesis cannot be accepted as true merely because it accounts for a phenomenon, for this may be done by two conflicting hypotheses, both of which, of course, cannot be true. For example, the succession of day and night can be accounted for equally by the two contradictory hypotheses of the sun

moving round the earth and the earth moving round the sun, and yet the latter hypothesis alone is true. The real use of hypothesis is to *suggest* lines of investigation which may enable us to arrive at inductive truths.

2. Definition of Hypothesis.—"An hypothesis is a supposition made without evidence, or with insufficient evidence of its own, in order to deduce conclusions in agreement with real facts, the agreement being the proof of the hypothesis".

—*Mill.*

"An hypothesis is a supposition, suggestion, or guess, as to any matter unknown, leading to experimental or other operations, for proof or disproof".

—*Bain.*

"*Hypothesis* is a name that may be applied to any conception by which the mind establishes relations between data of testimony, of perception, or of sense, so long as that conception is one among alternative possibilities, and is not referred to reality as a fact".*

—*Bosanquet.*

3. Nature of Hypothesis.—An Hypothesis implies the following things :—

(1) that a supposition or guess is made with the help of imagination ;

(2) that the evidence or authority for such a supposition is insufficient, and known to be so;

(3) that this supposition is intended to explain some fact or some law, which is known to be real.

4. Scope of Hypothesis.—"In scientific thought—no matter what the subject may be—every regularity or irregularity in the occurrence of events, for which no reason is apparent, every imperfectly understood or unexplained fact is a call for an hypothesis. And every hypothesis is a guide to further inquiry till the ultimate goal of explanation is reached; for, as Herschel says, 'we must never forget that it is principles, not phenomena,—the interpretation, not the mere knowledge of facts,—which are the objects of enquiry to the natural philosopher'". —*Welton.*

"An Hypothesis may be made concerning (1) an Agent, such as the ether; or (2) a Collocation, such as the plan of our solar system—whether geocentric or heliocentric; or (3) a Law of an agent's operation, as that light is transmitted by a wave-motion."

—*Carveth Read.*

5. Origin of Hypothesis.—The source of an Hypothesis is to be found either—

(1) in an induction based on grounds which are recognised as only probable; or

(2) in an analogy, or apparent resemblance between two phenomena.

An example of an hypothesis based on a probable induction is given by Joyce. When Brewster observed the colours of mother-of-pearl on the bees'-wax, his hypothesis that iridescence is caused by striation was only a probable induction.

The best example of an Analogical Hypothesis is that of James Watt as to the motive force of steam. He argued as follows :—

Ordinary agents employed to raise weights do so by the exercise of motive power ;
Steam resembles these agents in its power to raise the lid of a kettle ;
Steam may therefore be possessed of motive power.

The two modes of forming an hypothesis are at bottom the same, for the basis of every analogy is a probable induction. Both these forms of hypothesis depend for their value on the intelligence of the investigator, and not on a set of printed rules.

6. The Use of Hypothesis.—Hypotheses are by no means confined to the physical sciences : we make them freely in private life. In searching for an object which we have mislaid, in trying to account for the

unusual silence of a friend with whom we have been in regular correspondence, in estimating the character or explaining the conduct of acquaintances or of public men, we frame hypotheses. The only difference between the hypotheses of common life and those of scientific thought is that the latter need to be determined as completely and accurately as possible, till at length they satisfy all the demands made upon them as explanations of actual phenomena.

Hypotheses are essential aids to scientific discovery. Without the employment of hypotheses, science could never have attained its present state. Nearly all scientific laws were at one time mere hypotheses. For example, Newton's principle of Gravitation was at first an hypothesis, but is now universally accepted as a law.

It is said that Newton repudiated the employment of hypotheses in science in that famous utterance '*Hypotheses non fingo*' ('I do not frame hypotheses'). This is not true, for Newton himself made free use of hypotheses in his mathematical and astronomical investigations. What he meant was to protest against the use and acceptance of rash conjectures, and to condemn "hypothesis" in the sense of those premature assumptions that are sometimes made on altogether

insufficient grounds, which had been condemned by Bacon.

7. Conditions of a Valid Hypothesis.—Any guess or supposition is not an hypothesis: an hypothesis to be valid must fulfil the following conditions:—

(1) *The cause assumed must be a real cause, i.e.,* something of a kind known to exist in nature,—not a supernatural agent, nor a fiction of the poets. If a new agent be proposed, we should be able directly to observe it, or at least to obtain some evidence of its existence other than the very facts which it has been invented to explain. For example, if "wave-motion" is proposed as an agent to explain the phenomenon of Light, we should be able either to *see* what "wave-motion" is, or at least to obtain some proof of its existence apart from the phenomenon of Light.

(2) *The operation we ascribe to this assumed cause must not violate any of the known laws of nature.* This condition follows from the first, for unless a cause is real it cannot operate in a known manner. If, for example, an agent is spoken of as operating in defiance of the law of gravitation, we cannot accept it.

(3) *It must be adequate to account for the phenomena, at least so far as it professes to do so.* An hypothesis cannot be assailed if it does not explain a fact

that lies beyond its scope. Thus, it is no objection to an hypothesis of the origin of *species* that it does not explain the origin of *life*.

(4) *It must reconcile at least two different facts.* This is like the law of our criminal courts that to prove a crime there must be at least two witnesses. An hypothesis that explains one solitary fact cannot lead to the establishment of a *general* law, however narrow the generality may be.

(5) *It must be capable of verification.* It must admit of being proved or disproved either directly or indirectly. The direct mode of verification is by observation and experiment; the indirect mode consists in comparing the deduced results of the hypothesis with known facts or laws, or in showing "uncontradicted experience". A single case of contradiction with known facts or laws is fatal to an hypothesis.

Let us apply the foregoing tests to the hypothesis of the ancient Hindus that eclipses were caused by the demon Rahu's swallowing up the sun or moon. This hypothesis fulfils none of the above conditions:

(1) Rahu is a supernatural being or a fiction of the poets;

(2) the act of swallowing up such an enormous body as the sun or moon is contrary to all known laws of dietetics;

(3) it does not explain the whole phenomenon, for how does the sun or moon reappear in the same form after the swallowing?

(4) there is no other known instance of the heavenly bodies being swallowed up, by a demon or other devourer;

(5) it defies investigation, for we can subject neither Rahu nor his swallowing to the usual laboratory tests.

8. Cautions to be borne in mind when rejecting an Hypothesis. -If a supposition does not fulfil the conditions usually laid down for a valid hypothesis, it may not still deserve to be totally rejected, because—

(1) Even when an hypothesis cannot at once be established, it may still be a very promising one, not to be hastily rejected, since it may take many years to verify an hypothesis;

(2) Some facts may not be obtainable that are necessary to show the connection of others;

(3) An exception often proves the rule. On examination it may appear that an alleged exception is not really one, and that it serves rather to confirm the rule than to disprove it;

(4) An hypothesis originally intended to account for the whole of a phenomenon and failing to do so,

though it cannot be strictly said to be "established", may nevertheless contain an essential part of the explanation.

9. How far is Prediction a mark of a true Hypothesis?—Whewell lays great stress upon Prediction as a mark of a true hypothesis. Thus, astronomers predict eclipses long beforehand with the greatest accuracy, and this, according to Whewell, is a sure proof that the astronomical hypotheses on which these predictions are based, are true. But Mill rejects this view. He says that a predicted fact is only another fact, and that it is really not very extraordinary that an hypothesis that happens to agree with many known facts should also agree with some still undiscovered. There undoubtedly seems to be some illusion in the popular belief in the probative force of prediction. A prediction that comes true surprises us, and renders persuasion easy; but cases can be cited in which erroneous hypotheses have led to prediction; *e.g.* the Ptolemaic theory could predict eclipses and other celestial phenomena quite accurately, and yet it was proved to be a false theory.

10. Kinds of Hypothesis.—There are two chief kinds of hypothesis:—

(1) *Hypothesis of Cause.*—In this kind of hypothesis the assumed cause or agent is imaginary, but

it is shown to work according to known laws; *e.g.* the hypothesis which ascribes the propagation of heat and light to vibrations of a fluid called *ether*, which is supposed to pervade all space, but for the existence of which there is no sufficient evidence.

(2) *Hypothesis of Law.*—In this kind of hypothesis the cause is a real one, but the law according to which it operates is imaginary; *e.g.* the hypothesis which ascribes the origin of certain diseases to "bacilli"; the bacilli are real, because they have been proved to exist, but the exact manner in which they produce disease is imaginary.

11. **Working Hypothesis.**—An hypothesis, even though strictly not verifiable, may nevertheless be useful as a guide to further inquiry A *Working Hypothesis* is a provisional assumption which is likely to need large modifications before it will be found to give a satisfactory explanation of all the facts which it should account for. For example, the "Rat-Theory" of the propagation of plague is, so far, only a "working hypothesis".

12 **Gratuitous Hypothesis.**—A *Gratuitous Hypothesis* is one in which there is an assumption of an *unknown* and superfluous cause, even though the phenomenon is capable of being explained by the operation of

known causes, and without the intervention of this superfluous agent. For example, if the geological question concerning the transport of erratic boulders can be satisfactorily answered by the supposition that they have been washed down by water currents, the supposition of other agencies, like glaciers, or icebergs, or earthquakes, is superfluous and would be a "gratuitous hypothesis."

13. Crucial Instance, and Crucial Experiment.—The terms "Crucial Instance" and "Crucial Experiment" were used by Bacon to denote an observation or an experiment which decides between two rival hypotheses, and shows which is to be adopted and which rejected. They are called *crucial* (from Latin, *crux*, 'a finger-post') because they stand like sign-posts at the parting of the ways to guide us into the right path. The essence of a Crucial instance or Crucial experiment is that it should absolutely negative one hypothesis, and at the same time confirm another.

"Thus, when the Copernican system was brought forward in opposition to the Ptolemaic, not only was it necessary to show that the new system corresponded with all the facts, but there was farther required the production of some facts that it alone could conciliate. The first fact of this decisive character was the Aberration of Light, a fact incompatible with the earth's

being at rest. Another fact, equally decisive, was Foucault's pendulum." (—*Bain.*)

14. **Distinction between Hypothesis and Theory.**—A completely verified hypothesis is often called a *Theory*, though the latter term is also used for the whole body of laws pertaining to a certain class of phenomena, as when Astronomy is called the "theory of the heavens." Between hypothesis and theory in the former sense, no distinct line can be drawn; for the complete proof of a certain speculation may take a long time—sometimes several generations—and meanwhile the available mass of evidence produces in different minds different degrees of assurance; so that the upholders of the doctrine call it a "theory," while its opponents continue to call it an hypothesis.

15. **Distinction between Hypothesis and Abstraction.**—The term "hypothesis" is often confused with Abstractions, as when it is said that the reasonings of Geometry are built upon hypotheses. What is meant in saying so is that the figures assumed are abstractions, and do not correspond to any real things.

There are two important points of difference between Hypothesis and Abstraction:—

(1) Abstractions, like hypotheses, are necessary to science; but the conclusions drawn from abstract

terms are limited by their definitions, and cannot be applied to actual things without due corrections and allowances; whereas an hypothesis, if valid, is good enough for all practical purposes, without the need of limitations.

(2) An hypothesis assumes an agent, collocation, or law hitherto unknown; whereas abstract reasoning excludes from consideration a great deal that is well known. For example, in abstract reasoning a point merely marks position, and has no magnitude; whereas every real point possesses not only a certain magnitude, but also a certain colour, and certain material substance.

16. Distinction between Hypothesis and Assumption.—All hypotheses are assumptions, but all assumptions are not hypotheses. For sometimes assumptions are made to facilitate an investigation; *e.g.*, in estimating national wealth the assumption is frequently made that furniture is half the value of a house.

There are some assumptions that can never be proved by direct means. Their only merit is their convenience. Such assumptions are called "*Representative Fictions*"; *e.g.*, all statements as to the ultimate structure of the particles of matter are "fictions"; we can never prove them, yet since they are consistent with all appearances, and since they help us to connect the appearances

together in a general statement, they serve an important intellectual function.

A similar "fiction," in Political Economy, is that of an "economic man," whose activities are supposed to be guided entirely by the desire for wealth. Such "fictions" are most common in the science of Law.

17. Distinction between Hypothesis and Fact.—The term *Fact* is sometimes restricted to signify the particular concrete facts of experience. Sometimes it is extended to include whatever has been proved to be real, and in this sense the term *Fact* means the same as a *Theory* the truth of which has been established. An hypothesis which is completely verified is sometimes called a *Fact*.

18 Relation of Hypothesis to Discovery.—Discovery is almost entirely dependent on hypothesis. No one is likely to discover the law which lies hidden behind the complex phenomena of Nature, unless he hazards an hypothesis, and then by observation and experiment forces Nature to declare whether his hypothesis is true or not. Logic cannot teach the art of making hypotheses, much less can it lay down rules for discovery: it is only concerned with proof. The inductive methods are mainly methods of elimination and proof, and if they suggest new truths they do so only in an incidental way.

EXERCISES.

1. What is the true function of Hypothesis in Inductive Logic?

2. Define Hypothesis, and distinguish between an Hypothesis and (1) Theory, (2) Abstraction, (3) Assumption, and (4) Fact.

3. In what respect does a Scientific hypothesis differ from one of ordinary life?

4. What is the use of hypothesis in Science? What did Newton mean by saying that he did not frame hypotheses?

5. Enumerate the conditions of a valid hypothesis and apply these tests to an actual case.

6. If an hypothesis cannot be readily established, does it always follow that it is to be absolutely rejected? Give reasons.

7. Whewell calls prediction an essential mark of a true hypothesis. How far do you agree with this view? Give reasons.

8. Define each of the following:—Hypothesis of Cause, Hypothesis of Law, Working hypothesis, Gratuitous hypothesis.

9. What is the scope of an hypothesis?

10. What is a Crucial Instance, and why is it so called? Give an example.

11. What is the relation of Hypothesis to Discovery? How far does Logic aid in the process of discovery?

CHAPTER VI.

THE INDUCTIVE METHODS.

1. Nature of the Inductive Methods.—The Inductive Methods are, as their name denotes, *methods* of drawing *inductive* conclusions from the particular facts of experience.

(1) They direct us in conducting observations and experiments in such a manner as to justify us in drawing conclusions about causation;

(2) They lay down conditions of *proving* any proposition that predicates causation;

(3) They both suggest and prove hypotheses.

The Inductive methods are thus both methods of Discovery and methods of Proof. But Logic is concerned with them only as methods of proof.

2. How far are the Inductive Methods essentially methods of Elimination?—Some logicians hold that the principle underlying the Inductive Methods is that of *Elimination*, or separation of the unessential from the essential antecedents of a phenomenon. The actual method of elimination consists in varying the circumstances of the phenomenon under investigation, *i.e.*, trying by experiment to reproduce the phenomenon, or watching its recurrence in nature, under changing circumstances. The various antecedents,

among which the cause is to be looked for, are first tabulated, and then successively eliminated until only one remains ; this remaining antecedent is then declared to be the cause.

This view is regarded by other logicians as untenable. An argument conducted in this manner would ever remain inconclusive. We must not only eliminate those antecedents which are not the cause: we must have also positive grounds for asserting that the effect proceeds from such and such a fact and from no other. The Methods provide us with the material not only for Elimination, but also for Induction properly so callled. The object that we have in view in them is so to simplify our data that we shall no longer be bewildered by their complexity, but shall recognise the causal relation as it is exemplified in the individual case.

3. The Inductive Methods are based on the Law of Causation. The chief object of Induction being the discovery of causes, it follows that the Inductive Methods should all be based on the Law of Causation. Indeed, the principle underlying each of the Methods is a corollary of the Principle of Causation. The Law of Causation involves the following affirmations, each of which is the basis of a process of elimination and forms the principle of one of the Inductive Methods :—

(1) *Whatever antecedent can be left out without*

impairing the effect, can be no part of the cause. This rule follows from the Law of Causation, because according to this Law, cause and effect are *invariably* connected with each other, so that a *variable* antecedent, or one that is sometimes present and sometimes absent, cannot be the cause of a phenomenon. For example, if we cut a string which was supposed to be the support of a weight, and the weight does not fall, the string cannot be the cause of the support.

This aspect of Causation forms the principle of the *Method of Agreement.*

(2) *When an antecedent cannot be left out without the consequent disappearing, such antecedent must be the cause or some part of the cause.* This rule also follows from the Law of Causation, because according to this Law, cause and effect are *unconditionally* joined together, the absence of the cause being followed by the absence of the effect. For example, if on the cutting of the string the weight falls down, the string *is* the support of the weight.

This aspect of Causation forms the principle of the *Method of Difference.*

(3) *When an increase or decrease of the antecedent is followed by an increase or decrease of the consequent, then the antecedent is the cause of the consequent.* This

rule likewise follows from the Law of Causation, because according to this Law, cause and effect are *quantitatively equal* to each other. For example, when an increase in the temperature of a body is followed by an increase in its bulk, we infer that heat is the cause of the expansion.

This aspect of Causation forms the principle of the *Method of Concomitant Variations.*

(4) The above are the three chief methods of eliminating the unessential circumstances present in cause and effect. After considerable progress has been made in the discovery of causes, recourse may be had to another proceeding :—*viz. to allow for the influence of all known causes, and to attribute what remains of the effect to what remains of the cause.* This rule is only a variation of the second rule.

This method is called the *Method of Residues.*

(5) The method of Agreement may be employed negatively, *i.e.*, cases may be found where cause and effect are uniformly absent together. When this circumstance can be conjoined with the positive method it is called the *Joint Method of Agreement and Difference.*

4. Names of the Inductive Methods.—There are five Inductive or Experimental Methods—the Method

of Agreement, the method of Difference, the Joint Method of Agreement and Difference, the Method of Concomitant Variations, and the Method of Residues. They are associated with the name of Mill, though Mill himself gathered them from Herschel's *Preliminary Discourse on the Study of Natural Philosophy.* Mill *speaks* of four methods, but gives five. It seems to be the Joint Method of Agreement and Difference which he does not consider entitled to rank as a separate method.

I.—THE METHOD OF AGREEMENT.

1. **Canon of the Method of Agreement.**—" If two or more instances of a phenomenon under investigation have only one circumstance in common, that circumstance is the cause or the effect of the phenomenon".

2. **Requisites of this Method.**—This method depends upon observation of an invariable connection between the given phenomenon and one other circumstance. For this purpose we take as many instances as we can of the phenomenon and compare them together to find out in what points they agree. The circumstances which can be excluded without impairing the phenomenon, or which can be absent notwithstanding its presence are not causally connected with

it The unessential or variable circumstances being thus eliminated, the antecedent or consequent which is throughout present in all the instances must be the cause or the effect.

3. Symbolic Illustration.—The Method of Agreement may be symbolically represented as follows :—

	Antecedents.		*Consequents.*
(1)	A B C	followed by	p q r.
(2)	A B D	,,	p q s.
(3)	A C E	,,	p r t.
(4)	A D F	,,	p u v.

∴ A is the cause of p

Here we have taken four instances of a phenomenon, to see in what points they agree. Taking the first instance alone into view, p may be caused by A, or by B, or by C. But comparing this with the second instance we find that C is absent among the antecedents, but the effect p is still present. We infer therefore that C is not the cause of p. Comparing this again with the third instance, we find that B is absent among the antecedents, but the effect p still persists ; and we now infer that B is not the cause of p. B and C are thus eliminated. A alone remains among the

antecedents upto the last. Hence A is the cause of p.

The common factor through all the antecedents is A ; the common factor through all the consequents is p ; and we connect the two as cause and effect.

4 Concrete Examples.—(1) All solid metal bodies? wood also? are converted into liquid by the application of heat. The metal solid bodies may be of every possible variety—gold, silver, copper, &c. ; the only circumstance common to all the antecedents is the application of heat, and the invariable effect in each case is the conversion to liquid form. We infer accordingly that the application of heat is the cause of the liquefaction.

(2) It has always been found wherever a flower is of scarlet colour—whether the flower is a rose, a tulip, a lily—it is without fragrance. Now here there is great variety in the circumstances of the phenomenon,—the flower being of a different species in each case ; but the one thing common to all the antecedents is the scarlet colour, and the one thing invariably found among the consequents is the absence of fragrance. We conclude therefore that scarlet colour is the cause of the absence of fragrance in flowers.

(3) The concurrence between the east wind and the aggravation of rheumatism in rheumatic people is, according to this method, a case of causation.

5 Defects of the Method of Agreement.—The Method of Agreement is mainly a method of observation, and is hence imperfect. The inference drawn according to this method is highly probable, but not absolutely certain, for the following reasons:—

(1) It is hardly possible to observe *all* the antecedents of a phenomenon, for events may be so mixed up that we cannot distinguish which is cause and which is effect; it may be that the connected facts are not a case of causation but one of pure co-existence.

For example, the absence of fragrance in scarlet flowers is believed to be really a case of co-existence, since nothing has been found in the *scarlet* colour that should be scientifically destructive of fragrance.

Again, it has been noticed that men of remarkable intelligence have, in hundreds of cases, been also short-sighted. Can we infer that intelligence is the cause of short sight, or short sight the cause of intelligence?

(2) The cogency of proof by the method of Agreement depends upon the elimination of all irrelevant circumstances, for the rule is that whatever circumstance cannot be eliminated is a possible cause or effect. But Nature does not always provide the variety of circumstances requisite for a thorough elimination. Hence all that we can ordinarily infer according to this method is invariable sequence, not unconditional causation.

Thus, complete elimination is not possible in the case of the events of History, or the phenomena of Economics, or of Physiology. The method of Agreement is therefore a very uncertain guide in inquiring into the cause of a plentiful harvest, or a famine, or a case of illness, or the rise or fall of prices, &c.

(3) There may be plurality of causes, so that the same effect may have been produced by a different cause in each of the instances we have gathered for examination, and the antecedent that is present in them all happens to be a purely irrelevant circumstance.

St. G. Stock gives an excellent example of this particular defect. "If a doctor were to cure the same disease on three occasions by three different drugs administered each time in orange wine, it would not follow that orange wine was a grand specific for that form of malady".

(4) There may be intermixture of effects, that is, effects due to different causes may be mixed up in the same phenomenon.

For example, cases of fever may be made up of—(1) headache, due to exposure; (2) cough, due to cold; (3) indigestion, due to overloading the stomach; (4) aching of the joints, due to a touch of inherited rheumatism; &c. No agreement can be traced among such cases of fever, owing to the intermixture of effects.

6. Remedies of the Defects.—The defects to which the Method of Agreement is exposed do not totally frustrate the method or vitiate the inference.

For the inference may be rendered valid by the following methods :—

(1) by multiplying the instances observed; for the larger the number of instances chosen the less the chance of coincidence, and the greater the chance of a causal connection;

(2) by confirming the truth of the inference by means of negative instances; *i.e.*, by comparing the instances of the occurrence of the phenomenon with instances of its non-occurrence.

For example, if the orange wine (of the above example) were tried in more cases than three, and found successful in each, the orange wine would assuredly be taken as the cause of the cure.

The inference that the orange wine is the cause of the cure can be further confirmed by a negative instance, a case in which the orange wine is *not* given, and if this case does not result in a cure, there would be no doubt left about the curative power of the orange wine.

7. Uses of the Method of Agreement.—The Method of Agreement is the commonest mode of proof for all kinds of uniformity, whether of co-existence or of causation. Bain calls it the universal mode of proof for all connections whatever. By this method we can trace causes to their effects as well as effects to their causes. It is the only method of determining causation in cases which rely on observation alone, and in which experiment is impossible.

8. Comparison between the Method of Agreement and Induction by simple Enumeration.—In Induction by Simple Enumeration we collect a large number of instances and the inference is based merely on their *number*; whereas the Method of Agreement is a method of elimination in which the inference is based on the *character* of the selected instances, and not on their number.

II. - THE METHOD OF DIFFERENCE.

1 Canon of the Method of Difference.—"If an instance in which a phenomenon occurs, and an instance in which it does not occur, have every circumstance in common except one, that one occurring only in the first; the circumstance present in the first and absent in the second, is the cause or a part of the cause of the given phenomenon."

2. Requisites of this Method.—This method requires that we should take only two instances of a phenomenon; and that these two instances should be exactly alike in all respects, except that in the first there is one circumstance present which is absent in the second. If now we can detect some other circumstance which is present in the first and absent in the second, we conclude that these two circumstances are causally connected.

3 Symbolic Illustration.—The Method of Difference may be symbolically represented as follows :—

	Antecedents.		*Consequents.*
(1)	A B C D	followed by	p q r s.
(2)	— B C D	,,	— q r s.

∴ A is the cause of p.

Here we have taken two instances of a phenomenon that are exactly alike in all respects except that in the first A is present, and in the second A is absent. We can also detect one other circumstance which is present where A is present, and absent where A is absent—*viz.* p. We therefore infer that A and p are causally connected, for, the disappearance of A, is followed by the disappearance of p, there being no other change in the phenomenon.

Notice that in the symbolic illustration we have assumed which is antecedent and which is consequent. In complex cases it may not be always clear which is antecedent and which is consequent. In such cases all we can infer is that A and p are causally connected. Further observation is needed to determine which is which.

day

4. Concrete Examples.—In our everybody inferences we are constantly applying the method of Difference. The usual form is the sudden introduction

of some definite change, followed by another equally definite change. That the drinking of water quenches thirst, that the taking of tea dispels drowsiness, that the rising of the sun causes light and heat, that fire burns the hand if touched, &c. are all applications of this method in common experience.

The effect of certain medicines is also proved by this method. For example, a man is suffering from sleeplessness ; a narcotic is given to him, and he quickly falls asleep. We infer that the narcotic is the cause of the sleep. How ? There is no difference between the man's previous state of sleeplessness and his subsequent state of sleep, except that he took a narcotic. This circumstance (the taking of the narcotic) was present in the second state, but absent in the first ; and the presence of it is accompanied by the presence of sleep, and the absence of it by the absence of sleep. Therefore the taking of the narcotic was the cause of the sleep.

5. **Difficulties attending the application of the Method of Difference.**—The great difficulty of applying the Method of Difference to the phenomena of complex sciences, is the difficulty of finding two instances of a phenomenon that are exactly alike in all respects except one. Nature seldom offers such clear-cut instances for our speculations. Hence this method

does not work well in cases where we have to rely on observation ; it suits better in cases amenable to experiment, because in experiments planned by ourselves we can have a certainty of there being no difference between the two instances except the intervention of a particular known circumstance, of which we can watch the result.

The method of Difference can prove unreliable even in experiments, if the phenomena are such that a considerable time must elapse between the introduction of an agent and the manifestation of its effects, for in that case other changes may have occurred meanwhile to which these effects are really due. For example, if feeling unwell you take a medicine and some time later feel better, you cannot be sure that the medicine was the cause of your recovery, for other curative processes may have been at work during the same interval, such as food, rest, exercise, or recreation.

The consequence of changes in the legislature or the effects of the introduction of new reforms are also difficult to determine, because of this element of time, which gives a chance of interference both to counteracting and to co-operating causes.

6. Uses of the Method of Difference.—The method of Difference is the most useful method of science :

(1) A large part of our knowledge of nature and of living beings is gained by making experimental changes and watching the consequences. The immediate result affords the best proof of causation.

(2) The method of Difference is the great method of Experimental Science, and it is so effective that a single experiment according to this method, if satisfactorily performed, is sufficient to prove causation.

(3) An inference drawn according to this Method is not apt to be vitiated by plurality of causes, same as the method of Agreement is.

(4) This method is oftener than any other the unconscious basis of our ordinary judgments. In ordinary cases the method is so obvious in its application, so satisfactory and conclusive, as scarcely to need the aid of Logic: the special use of Logic consists in showing the precautions requisite in the more complicated cases.

7 **Comparison of the Method of Difference with the Method of Agreement.**—Beyond the single fact of both being ultimately based on the Law of Causation, there is nothing in common between these two methods:

(1) In the method of Agreement we compare instances with a view to detecting *resemblance*; in

the method of Difference we do so in order to detect *difference.*

(2) The method of Agreement is based on the principle that whatever *can* be eliminated is *not* the cause; the method of Difference is based on the principle that whatever *cannot* be eliminated *is* the cause.

(3) The method of Agreement needs a *large number* of instances, and the larger the number the more probable the inference; the method of Difference requires *only two* instances.

(4) The instances chosen in the method of Agreement must be as *various* as possible; those chosen for the method of Difference must be exactly *alike* in all respects except one.

(5) The method of Agreement is primarily a method of *observation*; the method of Difference is mainly a method of *experiment.*

(6) The method of Agreement is rendered doubtful by the plurality of causes and the intermixture of effects; the method of Difference is usually unaffected by these disturbances.

III.—THE JOINT METHOD OF AGREEMENT AND DIFFERENCE.

1. **Canon of the Joint Method.**—"If two or more instances in which a phenomenon occurs have only one

circumstance in common, while two or more instances in which it does not occur have nothing in common except the absence of that circumstance; then the circumstance in which alone the two sets of instances differ, is the effect or the cause of the phenomenon."

2. Requisites of this Method.—The Joint Method is a twofold application of the Method of Agreement,—first, to a set of instances in which a phenomenon is present, these being called *Positive Instances*; and secondly, to another set of instances in which a phenomenon is absent, these being called *Negative Instances*. The positive instances suggest an hypothesis which is verified by the negative instances.

Two conditions must, however, be fulfilled before the Joint Method can be applied:—

(1) The negative instances must resemble the positive ones in as many circumstances as possible, otherwise there would be no comparison between the two sets of instances.

(2) The negative instances must differ from the positive in more circumstances than one, otherwise the Method of Difference would be more applicable than the Joint Method.

3. Symbolic Illustration.—The Joint Method

may be symbolically represented as follows :—

First set of Instances (Positive.)

Antecedents.		*Consequents.*
A B C	followed by	p q r
A B D	"	p q s
A C E	"	p r t

∴ A is (probably) the cause of p.

Second set of Instances (Negative).

Antecedents.		*Consequents.*
B F G	followed by	q u v
C H J	"	r s t
D E I	"	w x y

Comparing these with the first set of instances we infer that A is the cause of p. The first set of instances give the conclusion that A is probably the cause of p, according to the method of Agreement, because wherever A is present, p is also present. We then try the second set of instances and notice that each time that A is absent, p is also absent. The conclusion that A is the cause of p is thus confirmed.

Notice also : (1) that the positive instances resemble the negative instances in four respects ; and (2) the negative instances differ from the positive in five respects.

4. Concrete Examples.—(1) It is by the Joint Method that it has been established that vaccination is

a preventive of small-pox; because wherever vaccination is present immunity from small-pox is also present (*i.e.*, there is no small-pox), and wherever vaccination is absent immunity from small-pox is also absent (*i. e.*, small-pox is prevalent).

(2) All substances that radiate heat quickly have large deposits of dew on them. From this fact we infer, by the Method of Agreement, that quick radiation is probably the cause of the deposit of dew. This conclusion is confirmed by the negative instances which show that where there is no quick radiation there is little or no deposit of dew.

(3) Whenever the East wind is blowing the result is the prevalence of sickness. By the Method of Agreement we infer that the East wind is the probable cause of the sickness. This conclusion is confirmed by the negative instances which show that when the East wind is not blowing there is no sickness.

5. Uses of the Joint Method.—The Joint Method is of great use in cases where experiment is impossible and where there is a large field for observation. Its peculiar advantage is that if the negative instances (*i.e.*, those in which the phenomenon and its supposed antecedent are absent together) can be made exhaustive, the proof becomes conclusive. For example, that a

gold currency is the cause of a country's wealth can be proved by the Joint Method, first by showing that all countries having a gold currency are wealthy, and next by showing that all countries having no gold currency are poor. If this latter list can be made exhaustive the proof becomes conclusive.

6. **Defects of the Joint Method.**—Since the Joint Method relies chiefly on observation, and not on experiment, it can never be very accurate or conclusive in proving causation. This is because the exact sequence of phenomena may not be clearly perceptible in the instances observed, and in such cases the conclusion may possess a high degree of probability, but cannot be quite certain.

7. **Comparison of the Joint Method with the Method of Difference.**—(1) The Joint Method is mainly a method of observation; the method of Difference is pre-eminently the method of experiment.

(2) The Joint method is applied in cases where the method of Difference cannot be employed; it thus serves as "the second best," in the absence of the very best.

(3) The Joint Method is more elaborate, more complicated, and perhaps more difficult than the Method

of Difference, though, like the Method of Difference, we all use it in our ordinary reasonings.

3. Comparison of the Joint Method with the Method of Agreement. - (1) The Joint Method is simply a double application of the Method of Agreement, first to a set of positive instances, and next to a set of negative instances.

(2) It serves to confirm the truth of an inference arrived at by the Method of Agreement.

(3) Like the method of Agreement, its conclusions may only be probable, not certain; for like the method of Agreement, it relies mainly on observation.

IV. - THE METHOD OF CONCOMITANT VARIATIONS.

1. Canon of the Method of Concomitant Variations.—"Whatever phenomenon varies in any manner whenever another phenomenon varies in some particular manner, is either a cause or an effect of the phenomenon".

2. Requisites of this Method.—Whenever we observe two phenomena varying together we may apply the method of Concomitant Variations. The concomitant variation of two phenomena, say, x and y, may take place in four ways :—

(1) the increase of x may be accompanied by the increase of y ;

(2) the increase of x may be accompanied by the decrease of y;

(3) the decrease of x may be accompanied by the increase of y;

(4) the decrease of x may be accompanied by the decrease of y.

In each of these four cases we are justified in asserting a causal connection between x and y.

3. Symbolic Illustration. – The Method of Concomitant Variations may be symbolically represented as follows :—

Antecedents.		*Consequents.*
A B C	followed by	p q r
A'BC	,,	p'qs
A''BC	,,	p''st

$\therefore$ A is the cause of p.

Here we notice that whenever A varies, p also varies. In the first instance, A is followed by p; in the second instance a particular variation of A, viz. A', is followed by a similar variation of p, viz. p'; in the third instance another variation of A, viz. A'' is followed by the same variation of p, viz. p''. We also notice that there is no variation in any of the other antecedents or consequents; and we conclude that A is the cause of p—provided we are sure that A is the antecedent and p the consequent.

4. Concrete Examples. (1) The amount of expansion which a solid undergoes is observed to vary with the degree of heat applied to it; therefore, heat is the cause of expansion.

(2) The higher the elevation of a place, the cooler is its climate; elevation is therefore an important factor in the determination of climate.

(3) It has been observed that crimes diminish in proportion as employment for workmen becomes abundant; therefore want of employment is the cause of crime.

5. Uses of the Method of Concomitant Variations.—There are certain natural forces, such as gravitation, heat, friction, that can never be eliminated completely, and therefore can only be studied in their degrees. We cannot, for example, deprive a body of *all* its heat; but by making changes in the amount we ascertain concomitant changes in the accompanying circumstances, and so can establish cause and effect. It is to those phenomena in which such natural forces as heat, gravitation, friction &c. play a part, that the method of Concomitant Variations is chiefly applicable. The peculiar use of this method is to formulate the conditions of proof in respect of those causes or effects which cannot entirely be got rid of, but can be obtained in greater or less amount. In other words,

the method is chiefly applicable to phenomena that have a *quantitative* aspect.

6. Defects of the Method of Concomitant Variations.—The Method of Concomitant Variations is subject to a number of limitations :—

(1) It is applicable to those cases only in which there are *quantitative* variations of antecedent and consequent—qualitative variations being beyond the province of this method. For example, in the following case, we can draw no inference, since the variation of the consequents is *qualitative*, while the variation of the antecedents is *quantitative* :—

Fever	100°	accompanied by	Headache.
,,	102°	,,	Pain all over the body.
,,	104°	,,	Restlessness and blood-shot eyes.
,,	106°	,,	unconsciousness.

(2) The Method can be applied only to those cases that have actually been observed or are capable of being verified ; we cannot extend our conclusion to cases that we have never observed.

(3) The variations have fixed limits. For example, the law that heat expands solid bodies cannot be extended to mean that a lady's finger-ring can, by the continuous application of heat, be expanded to the size of a carriage wheel.

(4) Two phenomena varying concomitantly may not be related as cause and effect, but may be joint effects of a common cause; *e.g.* the hour hand and minute hand of a watch vary concomitantly, but the motion of the one is not caused by the motion of the other: both motions being caused by the internal mechanism of the watch.

(5) There is risk of a case of *non-variation* being mistaken for one of inverse variation or proportionate variation ; *e.g.* the stature of human beings varies from region to region, and so does the climate of places ; but we cannot infer from this that variation in the stature of human beings is caused by the climate of the regions they inhabit.

(6) Parallel variation is sometimes interrupted by *critical points* ; *e.g.* in the expansion of bodies by heat the critical point is the freezing point. Similarly in the animal body food and stimulants operate proportionally upto a certain point, at which their further operation is checked by the peculiarities of the living organs.

(7) Very often a concomitant variation of cause and effect is not perceptible, until an unusual manifestation of the one is accompanied with an unusual manifestation of the other ; *e.g.* we may be using some hurtful article of food for a long time unknowingly,

and the discovery is made by an accidental increase of quantity occurring with an aggravation of some painful effect.

7. Comparison between the Method of Concomitant Variations and the Methods of Agreement and Difference.—In one sense, the Method of Concomitant Variations may be regarded as a special case of the method of Agreement or the method of Difference, since it tends to prove the cause or effect not of a phenomenon as a whole, but of some modification of it.

V.—THE METHOD OF RESIDUES.

1. Canon of the Method of Residues.—"Subduct from any phenomenon such part as is known by previous inductions to be the effect of certain antecedents, and the residue of the phenomenon is the effect of the remaining antecedents."

2. Requisites of this Method.—This method implies a knowledge of causes gained beforehand from previous inductions. It is therefore a more advanced method than the others, and is used in the study of a phenomenon that is completely explained but for a single unexplained element, which is called the *residue*.

3. Symbolic Illustration.—The Method of Residues may be symbolically represented as follows:—

Antecedents.		*Consequents.*
A B C D	followed by	p q r s
B C D	,,	q r s

∴ A is the cause of p.

Here we have a phenomenon, in which there are four antecedents followed by four consequents. Of these, three consequents, q r s, are known beforehand to be due to certain antecedents, BCD : the remaining consequent p is therefore due to the remaining antecedent A.

4. Concrete Examples.—(1) "The recorded dates of ancient eclipses having been found to differ from those assigned by calculation, it has been surmised that the average length of a day may in the meanwhile have increased. If so, this is a residuary phenomenon not accounted for by the causes ordinarily recognised as determining the rotation of the earth on its axis ; and it may be explained by the doctrine that the tides, by their friction, are reducing the rate of the earth's rotation, and thereby lengthening the day." (—*Carveth Read.*)

(2) Jevons cites as a simple instance the ascertaining of the exact weight of any commodity in a cart,

by weighing the cart and load, and then subtracting the known weight of the cart.

(3) The unforeseen effects of changes in legislation or of improvements in the useful arts, may often be discovered by the Method of Residues.

5. **How far is the Method of Residues a Deductive method?**—The negative instance in this method is constituted by deduction from the whole phenomenon $\frac{ABCD}{p\,q\,r\,s}$ by our knowledge of the laws of BCD; and this prominence of the deductive process has led some writers to class this method as deductive. But the fact is that all the Canons involve deductive reasoning, (as will be shown in Para. 1 of 'General Remarks on the Inductive Methods'). Then also a good many things in every experiment are assumed as already known; for example, what circumstances are material, and what circumstances are immaterial; when conditions may be called 'the same' and when not; &c.

6 **Uses of the Method of Residues.**—(1) The Method of Residues is one of the most important instruments of discovery, and is the most fertile in yielding unexpected results.

(2) The special value of this Method appears when some complex phenomenon has been for the most part accounted for by known causes, whilst there

remains some surplus or some balance, or some deviation which remains unexplained, and this residuary factor has to be explained in relation to the whole.

(3) As scientific explanation progresses, the phenomena that may be considered as residuary become more numerous, and the importance of this Method increases. Some of the latest and most important discoveries of science have been achieved by this method; *e.g.*, the discovery of Argon among the constituents of the atmosphere.

(4) The method is also useful where exact estimates of causes are not obtainable. For example, "Darwin having found certain modifications of animals in form, colouration, and habits, that were not clearly derivable from their struggle for existence in relation to other species or to external conditions, suggested that they were due to Sexual Selection." (—*Carveth Read.*)

7 **Comparison between the Method of Residues and the Method of Difference.**—The Method of Residues is a special modification of the Method of Difference,—the only difference between the two consisting in the way in which the negative instance is arrived at:

(1) In the Method of Difference, the negative instance is obtained by observation and experiment;

in the Method of Residues it is obtained by deduction from previous inductions ;

(2) The Method of Residues implies previous knowledge of the laws of separate causes and a deductive calculation of their joint effect ; the Method of Difference does not.

GENERAL REMARKS ON THE INDUCTIVE METHODS.

1. How far the Inductive Methods involve Deduction.—The Inductive Methods are really applications of deductive inference to the facts supplied by experience. They are called *inductive* methods only by courtesy. This will become clear if we fully exhibit the process of reasoning involved in the three principal methods, *viz.* Agreement, Difference, and Concomitant Variations.

In the Method of Agreement the reasoning is as follows :—

Whatever can be eliminated is not the cause of p ;
B, C, D, E, can be eliminated ;
∴ B, C, D, E, are not the cause of p.

But according to the Law of Causation, every event must have a cause. Therefore A is the cause.

In the Method of Difference the argument assumes the following form :—

Whatever cannot be eliminated is the cause ;
A cannot be eliminated ;
∴ A is the cause.

In the Method of Concomitant Variations, the reasoning is as follows :—

No *constant* factor can be the cause of *changes* in an effect ;
B, C, D, are constant factors ;
∴ B, C, D, are not the cause.

But every event must have a cause. Therefore the changes in p must have a cause. Therefore the changes in A are the cause of the changes in p.

In the same way it can be shown in the case of the other Methods that the reasoning is deductive throughout. The methods are *inductive* only in so far as the principle of each is derived from the Law of Causation, which is the essence of Induction.

2. Formal character of Inductive Logic.—Carveth Read points out how Inductive Logic may be regarded as having a merely formal character. For what does Inductive Logic really consist of? It consists :

(1) in a statement of the Law of Cause and Effect ;

(2) in certain immediate inferences from this Law, expressed in the form of the Canons;

(3) in the syllogistic application of the Canons to special propositions of Causation, by means of minor premisses showing that certain instances satisfy the Canons. Such is the bare Logic of Induction; so that, strictly speaking, the inductive methods of observation and experiment are no part of the Logic, but only a means of applying the Logic to actual propositions.

3. Whewell's Objection that the Inductive Methods assume Nature to be simplified. Whewell criticises Mill's Inductive Methods on the ground that they take for granted the very thing which is most difficult to accomplish—*viz.* the reduction of the phenomena of nature to the shape of simple formulas like "A B C followed by *pqr*". Nature's processes are extremely complex: she does not present to us events in such form that we can clearly discriminate between antecedents and consequents, or easily separate the essential from the non-essential circumstances.

Mill answers the objection thus:—It is quite true that it is very difficult first to obtain facts for inductive reasoning, and next to reduce them to the form adapted to one of the inductive methods. But before trying to reduce a fact, we must know the form to which the fact is to be reduced. So the Inductive Methods provide

us with rules or models to which inductive reasoning must conform if it is to be valid, just as the syllogistic rules provide us with means for testing the conclusions of deductive inferences.

4. Whewell's second Objection.—Whewell has brought another objection against the Inductive Methods, that "No discoveries were ever made by the employment of these methods."

Mill answers the objection thus :—

(1) This objection is an objection against all inferences from experience. If discoveries are made by observation and experiment, they are made with the aid of processes reducible to one or other of the Experimental Methods. Scientific discoveries may not be recorded exactly in the language of the Canons, but still we can detect in them the employment of the Canons.

(2) Even if the Inductive Methods be not methods of discovery, they are the sole methods of proof ; and it is with proof, as such, that Logic is principally concerned.

5. "The Methods bear a strong family likeness to one another."—There can be no question that the Methods bear a strong (and rather perplexing) resemblance to one another, because they are all based on the same principle—Causation. Agreement and

Difference resemble each other in so far as both are methods of elimination. The Joint Method is a double employment of the Method of Agreement,—to positive and to negative cases, its application to the negative instances being based on the principle of Difference. The Method of Residues is a special modification of the Method of Difference. The Method of Concomitant Variation is similarly a modification either of the Method of Agreement or of the Method of Difference. Each, by removing parts of a complex whole, (*i.e.* by elimination), seeks to establish a relation between the remaining parts. Thus the methods are, at bottom, all of them, Methods of Residues or Methods of Difference.

6. **The Methods aim at establishing Causation, yet they assume Causation.**—The object of the Methods is to establish laws of Causation. Yet, when we look at the Canons, we find that they can only work if the causal connection of the antecedents as a whole and the consequents as a whole is presupposed; for it is obvious that invariability of sequence (which is the essential mark of Causation) cannot be established by an examination of two or more instances. Mill himself acknowledges that the whole discussion proceeds upon a false assumption—*viz.* that A B C D, the aggregate of the phenomena existing at any

moment, consist of dissimilar facts, for each of which one and only one cause need be sought.

7. Welton's Criticism of the Method of Difference.—Mill regards the Method of Difference as the most important method, and as in itself capable of proving causation. This is not true: the Method of Difference is just as defective as the others. In the very example which Mill selects of a man shot through the heart, it is evident that there is no inference to cause. There is nothing to justify the assertion that if a man dies, he has been shot through the heart. The method, treated fairly, will not even, by itself, justify the universal proposition that if a man is shot through the heart, he dies. In such a case we do not argue "inductively" at all, but deductively, from our knowledge of physiology and of fire-arms. To test the method really, we must put ourselves in the position of one who has no such knowledge, and who has never seen firearms or wounds inflicted by them. Such a person would not be justified in drawing a universal conclusion.

EXERCISES.

1. What is the distinctive character of the Inductive Methods? How far are they essentially methods of elimination?

2. Show that the Inductive Methods are each based on the Law of Causation.

3. In what respects is the Method of Agreement open to objection ? How may this objection be removed ? In what kind of inquiries is it useful ?

4. What conditions must be fulfilled before applying the Method of Difference ? Show that the employment of this method is attended with peculiar difficulties.

5. What is the distinctive use of the Method of Difference ? How does it differ from the Method of Agreement ?

6. State the canon of the Joint Method. In what respects is this method an advantage over the Methods of Agreement and Difference ?

7. In what cases is the Method of Concomitant Variations to be applied ? Give one or two concrete examples of this method.

8. Name the defects of the Method of Concomitant Variations.

9. Describe the Method of Residues fully, with examples. In what points does it differ from the Method of Difference ? Does it involve any element of Deduction ?

10. Discuss whether the Inductive Methods can be properly called " inductive "

11. In what respect may Inductive Logic be called a *formal* science ?

12. " The Inductive Methods assume the very thing to be proved ". Discuss this fully.

13. Whewell brings forward the objection that " no discoveries were ever made by the employment of the Inductive Methods ". How far is this objection valid ?

14. Show that the various Inductive Methods are at bottom one and the same.

15. Show that the inductive methods, while aiming at proving Causation, tacitly assume Causation.

16. What claims does Mill put forward for the Method of Difference ? Are his claims justified ?

17. Examine the validity of the Inductive Methods as criteria of proof. Use illustrations.

18. England is the richest country in the world and has a gold currency. Russia and India, in proportion to population, are poor countries and have little or no gold currency. How far are such kinds of facts logically sufficient to prove that a gold currency is the cause of a nation's wealth.

19. A man having been shot through the heart immediately falls dead. Investigate the logical value of such a fact as proving that all men shot through the heart will fall dead.

20. How far does the validity of any of the Inductive Methods depend on the possibility of expressing Cause and Effect quantitatively ?

21. Explain and examine the view that plurality of causes renders the Method of Agreement uncertain.

22. What inductive inferences, if any, can you draw from the following, and according to what Method :—

(*a*) Wherever there are volcanoes earthquakes are frequent.

(*b*) A man finds that whenever he takes meat he suffers from constipation, which disappears the first day he abstains from meat.

(*c*) It has been invariably observed that mosquitoes are plentiful in the rainy season, but in other seasons not so.

(*d*) It has been frequently noticed that in seasons in which the mango crop is scanty, the *Neem* crop is abundant, and *vice versa*.

(e) A man, who never took any *bhang* before, takes it one evening on the recommendation of a friend who told him it acted as a great appetiser in his case. Strangely enough, this other man finds it the same.

(f) I was once suffering from a splitting headache ; a friend came and rubbed a menthol cone on my forehead, and the headache was instantly gone.

(g) Norway and Sweden have striking points of resemblance in respect of geographical position, climate, population, products and industries, &c. But Norway is much poorer than Sweden in national wealth. Further inquiry reveals the fact that Norway adopts a policy of Protection, while Sweden has free trade.

(h) "I own myself entirely satisfied that there is no such thing as colour really inhering in external bodies, but that it is altogether in the light. And what confirms me in this opinion is that in proportion to the light, colours are still more or less vivid ; and if there be no light, then there are no colours perceived." (Berkeley).

(i) The wealthiest nations in the world are Christian.

(j) Seasons of famine are invariably followed by seasons of cholera.

(k) As long as a certain player was captain of a cricket team, it always won ; whilst, after he retired, it always lost matches.

(l) A man finds that whenever he eats cucumber he suffers from indigestion.

(m) Colour and marking are constant in each species of wild animal, while, in almost every domesticated animal, there arises great variability.

(n) The shore of Norway is washed by the Gulf Stream, and the climate of Norway is temperate; the shore of Japan is washed by the Kuro Siwo, and Japan has a temperate climate; the shore of Newfoundland is traversed by a cold current from Greenland, and Newfoundland has a very cold climate.

(o) When in 1841 the railway from Rouen to Paris was being constructed, gangs of English and French workmen were employed upon it, and the English got through about one-third more work per man than the French. It was noticed that the English workmen took better food than the French.

(p) As the winter advances the ptarmigan changes its colour from brown to white.

(q) Prof. Ferri, in his *Criminal Sociology*, says: "I have shown that in France there is a manifest correspondence between the number of homicides assaults, and malicious wounding, and the more or less abundant vintage".

(r) As the duty on tobacco falls the price of it rises and the consumption of it also increases.

(s) During the last fifty years in India crime has decreased whilst education has increased.

(t) A certain village had in 1890 five wine-shops, and there were 100 cases of drunkenness in that year; in 1892 it had four wine-shops, and there were 80 cases of drunkenness; in 1894 it had three wine-shops, and there were 60 cases of drunkenness.

(u) As the winter advances the days grow shorter; as it nears its end they grow longer. Similarly as the summer

advances the days grow longer, and as it nears its end they grow shorter.

(*v*) The temperature falls one degree for every 300 feet of elevation.

(*w*) Two men travelling together halt at an inn after a long and fatiguing journey. Both order a dinner, which they partake together. One of them takes a peg before retiring, and shortly after has a violent colic. The other enjoys sound sleep.

(*x*) The houses of a certain hill station in India are all built on the south slope of the hill.

(*y*) We find in the languages of India and of Great Britain a very considerable number of names almost the very same in sound and applied to the same objects.

(*z*) A high degree of longevity is found in thinly-peopled districts, and mortality reaches its maximum in the most crowded parts of cities.

CHAPTER VII.

IMPERFECT INDUCTIONS.

1. **Scope of the Chapter.**—In this chapter we shall give an account of all those forms of reasoning that are improperly called Inductions. This is the sense in which the term "Imperfect Inductions" has been used in the University Syllabus of Inductive Logic,—and at the heading of this Chapter; *i.e.*, as meaning 'modes of reasoning that do not fulfil the conditions of a true induction'. The term "Imperfect Induction" is however more commonly used to denote an induction of the true type, which is called *imperfect*, because the inference is drawn after examining *only a few* instances, not all. This feature—*viz.*, the leap from the known to the unknown—is, according to Mill and his followers, an essential mark of a true induction; for if there be no passage from the observed to the unobserved, there is no progress of knowledge.

An induction which is improperly called Induction bears different names in different text-books of Logic,—Perfect Induction, Apparent Induction, Formal Induction, False Induction, Scholastic Induction, Complete Induction, Socratic Induction, these are some of the names by which it is designated by different logicians.

There are different kinds of "imperfect" inductions, the irregularity of which will be pointed out in this

chapter. These are :—Induction by Simple Enumeration, Mathematical Induction, Reasoning from Chance, Probable Reasoning, and Analogy.

2. Distinction between Perfect and Imperfect Induction.—Inductive proofs may be divided into two classes—Perfect and Imperfect. They are said to be *Perfect*, when *all* the instances of a given phenomenon have been severally examined and the conclusion has been found true in each case. They are said to be *Imperfect*, when only *some* instances of a given phenomenon have been examined, and the conclusion is believed to be true of all similar cases.

In a Perfect Induction the universal conclusion at which we arrive is no wider than the sum of the particulars ; in an Imperfect Induction the conclusion is extended beyond the cases examined, so as to include all like cases.

3. Nature of Perfect or Complete Induction.—In Perfect Induction we assert of a whole class what has already been found true of every individual member of that class Such inductions are possible only in the case of a class that is limited by nature, or which is artificially limited. For example, if after ascertaining that January, February, March, April, May, June, July, August, September, October, November, and December, has each less than 32 days, we

affirm that 'All the months of the year have less than 32 days', our affirmation is a Perfect Induction, because all possible cases have been examined. In this example the class is limited by nature.

A class may also be limited artificially in order to draw a Perfect induction. For example, we may consider the class 'the present Municipal Board of Allahabad'; we may examine the qualifications of every individual member, and find that each one is a graduate; and we may affirm, 'All the members of the present Municipal Board of Allahabad are Graduates'. This is also a Perfect induction, because all possible instances have been examined.

4. Perfect Induction expressed in the Form of a Syllogism.—Perfect Induction is the exact reverse of Deduction. In Deduction we argue from the universal subject to each and all of the particulars contained under it; in Perfect Induction we argue from each and all of a number of particulars to the universal subject.

A Perfect induction may be expressed in the form of a Syllogism, in Figure III, *Darapti*, with only this characteristic that the minor premiss of the syllogism has its subject and predicate co-extensive or of equal extent. For example—

January February.........December have less than 32 days ;
January, February.........December are *all* the months of the year ;
∴ All the months of the year have less than 32 days.

According to the rules of the Syllogism the conclusion is invalid, because the argument being in the III Figure, the conclusion must be particular. But this anomaly may be avoided by transposing the terms in the minor premiss, and getting the I Figure.

Still such a syllogism is no true syllogism, for there is no need of logical method to find the major premiss ; *it is mere counting* ; and to build up the syllogism is a hollow formality. Hence a Perfect Induction is also called an *Induction by Simple Enumeration*, because the major premiss is arrived at by mere counting.

5. **Perfect Induction is no true Induction.**—According to Mill, Perfect Induction is no true induction at all, for the following reasons :—

(1) The conclusion is really not a general proposition, but a mere reassertion, in briefer form, a mere summing up, of the particular premisses.

(2) The general term in the conclusion is not the name of each of an unlimited number of things,

but only of each of a limited number of known individuals.

(3) There is no inference from facts known to facts unknown, but a mere shorthand registration of facts known; that is to say, the conclusion does not advance beyond the premisses—it contains no new truth.

Hence, according to Mill, Perfect Induction is of no scientific value whatever, because the conclusion does not rely on the uniformity of Nature, nor is based on the principle of Causation.

6. The Practical Utility of Perfect Induction.—Though Perfect Induction is not induction in the strict sense, it is nevertheless of great practical utility. "It has the same function as Deduction; it renders implicit knowledge explicit. We are enabled to realise what we had not realised before, to trace a universal law where we had not suspected one. It brings out some universal characteristic of a class, teaches us to recognise in those who are bound together as members of that class the possession of a common peculiarity which before we had only recognised as belonging to them as individuals. It is true that this sort of induction does not establish any connection by way of cause and effect between the common property and the common class. But still it may suggest matter for

thought. For example, if I go into the room of a friend and find his library consists of ten books and ten only, and on examining them I find that they are one and all books describing travels in China or Japan, a perfect induction enables me to lay down—

'All my friend's books are books of travel in China and Japan'.

This suggests to me a train of thought that would never have arisen had I confined myself to the isolated fact respecting the nature of each book. Looking at them one by one, my thoughts are directed merely to the character of each, and the individual facts narrated in it. Looking at them together, I begin to think that my friend must either have been travelling in China or Japan, or that he is intending to go there, or that he must have friends in one or other of these countries, or that he is proposing to write an article on the subject, or that for some reason or other he must have a special interest in China and Japan."

(—*Clarke.*)

7. The weak point in Induction by Simple Enumeration.— The weak point in Induction by Simple Enumeration is that in the majority of cases we are not perfectly sure that the enumeration is complete. We think we have taken into account *all* the particulars, without overlooking a single case, and on this

ground we argue to the universal law; whereas all the while there is perhaps an instance that for some reason has escaped our notice, and perhaps the omission of this single case is fatal to the universality of our law. For example, let us suppose an eighteenth century chemist arguing about the then known metals thus:—

Iron, copper, silver, gold, lead, tin, mercury,
antimony, bismuth, nickel, platinum,
and aluminium, are all heavier than water;
Iron, copper, silver, gold, lead, tin, mercury,
antimony, bismuth, nickel, platinum,
and aluminium are *all* the metals;
∴ All the metals are heavier than water.

This would be a complete or perfect induction of the metals then known; but still the conclusion would be false; for since that time potassium, sodium, lithium, &c. have been pronounced to be metals, and all these are *lighter* than water.

Only in a few rare cases can an enumeration be exhaustive, and this is the weak point of all inductions by simple enumeration. Of course in the case of groups artificially restricted or cut down to narrow limits, *e.g.*, 'the members of the present Cabinet', 'the reigning sovereigns of the world', 'the hill-stations of India', 'the advocates of the Allahabad High Court', 'the

horses kept at the Viceroy's stables, Dehra Dun' &c, a complete enumeration is possible; but statements about these artificial groups are worth little more than a mere summing-up of facts already known

8. **Traduction.**—The name *Traduction* is often given to that form of inference in which the reasoning is from particulars to particulars, or in which the consequent is just as wide as the antecedent. For example, a child finds that several little frogs which he touches are cold, and he thereafter expects that other frogs will feel cold if he touches them. He does not consciously formulate any conclusion of this kind; there is simply the unconscious expectation of finding his previous experience repeated.

9 **Mathematical Inductions.**—Mathematical Inductions are only apparent inductions. This will appear from a consideration of the illustrations given below, which have been taken from three different branches of mathematics :—

(1) *Illustration from Conic Sections.*—By proving upon a circle, an ellipse, a parabola and a hyperbola that a straight line cannot meet any of these figures at more than two points, we lay down the universal proposition, 'A straight line cannot meet a conic section at more than two points'. This is a true generalisation

because the circle, the ellipse, the parabola, and the hyperbola are all the conic sections possible; but still this is not a true induction, as the conclusion is a mere summing-up of the particulars, containing no new truth, representing no advance in knowledge.

(2) *Illustration from Geometry.*—It is proved of a particular triangle ABC that its three angles are together equal to two right angles, and from this we proceed to lay down the universal proposition, 'All triangles have their three angles equal to two right angles'. This is a correct generalisation, but not a true induction, because the truth arrived at is not believed on the evidence of the particular case examined, but because we perceive that the process of demonstration which is applied to one case might equally well be applied to all. In one sense we may say that the demonstration never referred to a particular triangle at all, because there was no reference made to its size, its colour, its position, its material; in fact, no elements of observation were included in the argument at all; the demonstration was founded on the abstract idea of a triangle, or the concept of a three-sided figure. There is therefore in such a case no true induction.

(3) *Illustration from Arithmetic.*—Take the following arithmetic series :—1, 7, 31, 127. Each of these is

an odd power of 2, minus 1 :—

1st power, $2-1=1$
3rd power, $8-1=7$
5th power, $32-1=31$
7th power, $128-1=127$

Each term of the series is also a prime number. These particular instances may lead one to lay down the universal proposition, 'All odd powers of 2 diminished by 1, are prime numbers'. But the conclusion is false, for if we try the next term of the series, we see that the ninth power of 2 diminished by 1 is 511, which is not a prime number at all, because it is divisible by 7. This is an example of an induction by simple enumeration upset by a contradictory instance.

Arithmetical inductions, laying down what is called the *law* of a numerical series, cannot properly be called induction, for the conviction of uniformity rests on *a priori* considerations, and not on observation of concrete facts. This kind of reasoning is generally called Mathematical Induction, but Mill calls it *Parity of Reasoning*.

10. Reasoning from Chance.—Reasoning from Chance is perhaps the worst form of improper induction. Because a man has once picked up a rupee from a particular spot, he cannot argue that he will find a

rupee there every day. The principle of Chance is embodied in a well-known Hindustani proverb, "A blind man catching a quail". Chance was once believed to be a deity disturbing the ordinary course of Nature. But now Logic tells us that every event must have a cause, and yet we speak of events having occurred "by chance." What is meant by 'chance' in such cases is that the cause of the event attributed to it, is so remote that the causal connection cannot be traced. A *Chance Coincidence* means a conjunction of phenomena that are not known to be causally connected, or from which we have no ground to infer uniformity. There is thus a radical difference between a true Induction and a Generalisation from Chance.

11. Probable Reasoning. Probable Reasoning consists in drawing an inference from a proposition which is only approximately true. Propositions of the form 'Most S is P' are called *Approximate Generalisations*, because they are only *nearly* universal. Proverbs, common sayings, aphorisms, maxims, &c. are instances of Approximate Generalisation. They are propositions which have been found true in the course of long experience, for which reason they are also called *Empirical Generalisations*. They too are only approximate, because they can be relied upon only within

the actual limits of time, place, and circumstance where they have been observed to be true.

Approximate Generalisations, though often useful in practical life, are almost valueless in science. They are sometimes used as *materials* for universal truths, but they are not universal truths themselves. They lack precision and certainty, and are therefore useless as a means of discovering truths. When used as the major premiss of a syllogism, they can only yield approximate conclusions, and sometimes no conclusions at all.

When correct statistics are available, or the exact conditions of a fact are known, we can make so explicit an assertion that the approximate generalisation will approach a universal truth. For example, by a series of provisos or exceptions we may express an approximate rule in the form of a certain law.

12. What is Probability ?—'Probability' is an ambiguous term. In ordinary speech, when we say that an event is 'probable', we mean that it is more likely to occur than not to occur. In scientific language, an event is said to be 'probable' if our expectation of its occurrence is less than certainty, as long as the event is not impossible.

13. Ground of Probability.—There are two views as to the grounds of probability :—

(1) According to one view, Probability depends

upon the quantity of our *belief* in the happening of a certain event, or in its happening in a particular way.

(2) According to the other view, the ground of probability is *experience*. The first view is obviously unsound, because—

(*a*) belief cannot by itself be satisfactorily measured ;

(*b*) because it does not uniformly correspond with the state of the facts.

Hence if Probability is to be connected with Inductive Logic, it must rest on the same ground, namely, —Observation. Induction is not concerned with beliefs or opinions, but aims at testing, verifying, or correcting them by appealing to facts.

14. Relation of Probability to Induction.— There are two views on this question :—

(1) *That Induction is based on probability.*— Those who maintain this view do so on the following grounds :—

(*a*) that the subtlety, complexity, and secrecy of nature are such that we are never quite sure that we fully know even what we have observed ;

and (*b*) that the laws of nature may be altered, because the conditions of the universe may change at any moment.

(2) *That Probability is based on Inductions.*— In all reference respecting the probability of a fact we trust solely to induction from a sufficiently prolonged basis of actual observation.

The first view is clearly untenable. For our inductive inferences are probable in the same sense in which all other truths are probable, *i.e.* in being relative to the present constitution of nature and of the human mind,—a limitation to which all our knowledge alike is subject, and which it is vain for us to attempt to transcend.

The second view is reasonable. The probability of an event is calculated on the basis of the number of times it has been known to occur in the past. For example, if in the course of many years it appears that in the month of July in Allahabad, there have been four rainy days for three rainless ones, then, it is a matter of inductive certainty that the same proportion will hold in the future.

The evidence for probable inferences is, in the absence of causation, either (1) statistics, or (2) specific experience.

15. **Reasoning from Analogy.** – Reasoning from Analogy is a kind of probable reasoning, and therefore cannot constitute true induction. In analogy we

argue that if two things resemble each other in several points they will probably resemble each other also in other points.

16 Definition of Analogy.—" Analogy may be defined as a kind of probable proof which supposes that two things from resembling each other in a number of points, may also resemble in some other point, which other point is not known to be connected with the agreeing points by a law of causation or of co-existence".

—*Bain.*

" Analogy is a kind of probable proof based upon imperfect similarity between the data of comparison and the subject of our inference".

—*Carveth Read.*

" Analogy is an inference based on similitude".

—*Joyce.*

The fundamental principle of Analogy is, that of like things under like conditions like assertions are true,—which is only one form of the Law of Identity.

17. Aristotle's Definition of Analogy.—Aristotle defines Analogy as 'equality of ratios', or 'resemblance in relations'. We are said to argue from Analogy when having laid down that—

$$a : b :: c : d$$

we infer that what holds true of the relation between *a* and *b* will hold true also of the relation between *c* and *d*.

The following examples of Analogy, in the old Greek sense, are given by Stock :—

(1) As health is to the body, so is virtue to the soul.

(2) As a child is to its parent, so is a colony to its mother country.

(3) As evening is to day, so is old age to life.

(4) As the adjective is to the substantive, so is the adverb to the verb.

Such reasonings from analogy are very effective in argument or debate, but practically worthless as proof. To prove that an analogy is real and substantial will usually take more trouble than to prove the original point without the assistance of analogy.

18. **Analogy and Deduction.**—Like Deduction, Analogy assumes that things which are alike in some respects are alike in others ; but it differs from Deduction, inasmuch as Deduction relies on a law specifying the nature of the resemblance upon which the argument relies, and this law is the "*Dictum de omni et nullo*"; whereas Analogy relies upon no law of thought,

but is guided by mere imagination or caprice. Deduction consists in argumentation, Analogy in mere similitude.

19. **Analogy and Induction.**—Analogy is a weak form of induction. In both the argument is based on resemblance ; but—

(1) in Induction the points of resemblance are fundamental or essential properties of objects, whereas in Analogy it is not known whether the properties are essential or non-essential ;

(2) in Induction the observed common properties and the inferred property are known to be connected with each other by the Law of Causation ; in Analogy the two sets of properties are not known to be either connected or unconnected.

20. **Value of Analogical Reasoning.**—The cogency of all modes of proof depends upon the *character* and definiteness of the likeness which one phenomenon bears to another ; but the Analogical form of reasoning trusts to the general *quantity* of the likeness between them, regardless of what may be the really important points of likeness. Hence analogical reasoning is always weak. Analogy can never amount to full proof : at best it gives only a probable inference, and the probability too is of varying degrees, which

degrees are determined by the following rules framed by Mill :—

(1) The greater the number and importance of the points of agreement the more probable is the inference.

(2) The greater the number and importance of the points of difference the less probable is the inference.

(3) The greater the number of unknown properties the less the value of any inference based on the unknown properties.

Joyce criticises Mill in the following manner :—

But such a basis of analogy presents many difficulties. The mere *number* of resemblances is a point of little importance. The value of the inference depends on the *reasons* which we possess for supposing that the characteristic common to the two objects is really connected with the property in question. These reasons, however, must not be such as to amount to certainty. They must be probable, not conclusive. But it is they that are the true foundation of the argument : and where they are wanting analogy becomes mere guess-work. Moreover, Mill's demand that a comparison should be instituted between the known points of agreement and difference on the one hand, and the

unknown properties, on the other, is incapable of fulfilment. Since the region is unexplored, any attempt to form an estimate of the number of properties which it contains, must needs be fruitless.

EXERCISES.

1. What do you understand by Imperfect Inductions? Point out any ambiguity that you think may attach to the expression.

2. What is a "perfect" induction? Clearly distinguish between perfect and imperfect inductions.

3. Can perfect induction be expressed in the form of a syllogism? Give reasons for your answer.

4. Define Induction by Simple Enumeration. Give an example. In what cases is such an induction possible?

5. Prove that Perfect Induction is not a true induction at all?

6. Show by an example that Perfect Induction, though of little scientific value, is of great practical utility.

7. What is the weak point in Induction by Simple Enumeration.

8. Define 'Traduction', and give an example.

9. Discuss whether mathematical inductions can be regarded as true inductions. Illustrate your arguments.

10. Enumerate all the varieties of Imperfect or improper inductions, and show briefly that none is entitled to be regarded as a true induction.

11. How far is reasoning from Chance a true generalisation?

12. What do you understand by "Empirical Laws"? In what sense can they be called "laws"?

13. Define Probability and state what you believe to be the ground of it, referring to and criticising any opposite views that you may know of.

14. What is the relation of Probability to Induction ? Are logicians unanimous on this question ? What is your own view ?

15. How far may reasoning by analogy be regarded as true induction ?

16. What is Analogy ? Distinguish between the modern and the ancient use of the term. Give one or two concrete examples.

17. State the relation of Analogy (1) to Deduction, and (2) to Induction.

18. What is the value of analogical reasoning, and on what does this value depend ?

19. State and criticise Mill's method of testing the value of an analogical argument.

20. Examine the following arguments :—

(*a*) AB went up for the B. A. Examination last year, and failed ; probably he will fail this year again.

(*b*) Some people say that the Government would make much profit by reducing the charge for telegrams, and the passenger fares for railways, to the same low rates that are required for letters and packets. They point to the Post Office as the most profitable department of the Government, although it charges only a half anna for letters.

(*c*) Some astronomers are of opinion that the planet Mars is inhabited, because like the Earth it is a solid body, opaque, spherical, and having an atmosphere, sea, and land.

(*d*) The march of human history is like the flow of the tides.

(*e*) The State is like a family, and the King is therefore like a patriarch—absolute and all-powerful.

(*f*) A quadruped resembles a human being in many points of structure and function; therefore it is likely that he also possesses a moral faculty like our conscience.

(*g*) The war between Athens and Sparta was a war between a sea power and a land power; and the war lasted for many years. Therefore, since the war between Rome and Carthage was also a war between a land power and a sea power, it could easily have been inferred that this war too would continue for many years.

(*h*) As in matter we may have a plurality of forces conspiring or opposing each other, so in mind we have motives uniting or opposing each other.

21. "Analogy is the soul of Induction". Criticise this statement.

22. Consider the relations that have been held to exist between analogy and induction. Do you think there is ever proof from analogy? If not, what place does analogy hold in the process of inference?

23. "The Third Figure is distinctively the *Inductive Figure*". Discuss this view of the nature of the inductive process.

24. Criticise the view that induction is based on the theory of probability.

25. "Induction by simple enumeration can never lead, in itself, to more than an empirical law". Discuss this.

CHAPTER VIII.

RELATION OF INDUCTION TO DEDUCTION.

1. Four Stages of an Inductive Inquiry. Inductive Logic teaches us by what kind of reasoning we can gather the laws of nature from the facts and events of the outward world. There are four steps in an inductive inquiry or scientific investigation :—

(1) *Preliminary Observation.*—At the very outset of our inquiry we should gain, by almost accidental observations and by natural experiments, a knowledge of facts relating to the subject of inquiry. The facts so gained are, of course, disconnected, and do not enable us to explain other facts: it is merely knowledge given by the senses.

(2) *Framing an Hypothesis.*—We next proceed to reason about these facts, by conjecturing laws which may be true of the things examined. This is called "framing an hypothesis"—which means supposing a law or general proposition to be true for the sake of argument.

(3) *Deductive Reasoning.*—Next, we reason, by the syllogism or other kinds of deductive argument, to the particular facts which will be true if the hypothesis be true.

(4) *Verification.*—Lastly, we proceed to compare these deductions with the facts already collected, or if

necessary, to make fresh observations and experiments so as to find out whether the hypothesis agrees with nature. If it does not, we must modify our hypothesis or frame a new one altogether, and proceed afresh.

2. Different Sciences employ these operations in different degrees.—Almost every science consists of truths arrived at partly by induction, partly by deduction. In some sciences the inductive part is comparatively small, and the deductive part very large; *e.g.*, Physics and Political Economy. In other sciences, the deductive part is very small, and the science mainly consists of general truths which have been discovered by means of induction; *e.g.*, Botany and Zoology.

3. These Steps involve Deduction.—In every scientific inquiry deduction must be employed in conjunction with induction, otherwise no result follows. Of the four stages of an inductive inquiry—Observation, Hypothesis, Reasoning, Verification—the first alone is strictly inductive, the other three all involving deduction, more or less:—

With the very process of framing an hypothesis we make a rapid mental calculation as to whether the hypothesis fits in with facts that have been observed; and this involves deductive reasoning.

The third step is professedly deductive.

The last step, Verification, is again deductive, and consists in applying the hypothesis to unobserved facts, by making fresh observations and experiments; and this process, like the second step, involves deductive reasoning.

4. Can the Deductive Syllogism not supplant the Inductive Method completely?—Seeing that the inductive method contains such a large admixture of deduction, the question naturally arises, Can the Syllogism not replace the inductive method completely? It is true that in the inductive process the first step alone—that of preliminary observation—is properly inductive; and that full three-fourths of the work of investigation is really performed by deduction. Even for the work of observation and experiment, Inductive Logic declines to lay down any rules. Still, the syllogism is barren of new truths: it needs the help of induction at the very start; for the premisses of a syllogism are obtained by induction, *i.e.*, by observation and experiment. Besides, the syllogism may in any case be regarded as either useless or fallacious. As Carveth Read points out, "If *all* the facts of the major premiss have been examined, the syllogism is needless; and if *some* of them have not been examined, it is a *petitio principii*. But either all have been examined,

or some have not. Therefore the syllogism is either useless or fallacious".

5. Points of Similarity between Deduction and Induction.—(1) In both we have to consider the conditions of truth,—only, that in deduction it is *formal* truth, in induction, *material.*

(2) In both the reasoning turns upon the existence of *resemblance* between things; *i.e.*, the question, 'What sort of resemblance is a sufficient ground of inference?' is the important question in Deduction and Induction alike.

(3) The *Dictum de omni et nullo*, which forms the axiom of Deduction may, by a slight modification, be applied to inductive reasoning as well. "Whatever is true of a whole class is true of everything contained in the class" may be restated in a slightly modified form thus:—"Whatever we have reason to regard as constantly connected with the nature or connotation of a class or class-name, we may expect to be similarly connected with whatever can be shown to have that nature or connotation". Or, in other words, "Whatever has a mark has that of which it is a mark".

6. How far are the Inductive Methods strictly inductive?—The formal character of Inductive Logic has already been pointed out in Chapter VI. It remains only to show that the Inductive Methods are

not sufficiently inductive at all. The Canons profess to lay down the conditions of proving directly, by means of observation or experiment, any proposition that predicates causation. But observation and experiment are not the only means of proof, for the Law of Causation is an indispensable foundation of the evidence, so much so, indeed, that the Canons themselves are only immediate inferences from this Law, stated in an expanded form. Then again the application of the Canons to particular propositions of causation is purely syllogistic. As Prof. Ray points out, the reasoning in the case of each of the Methods may be expressed as follows :—

> "Whatever relation of events has certain marks is a case of Causation ;
>
> The relation of A to p has some or all of these marks ;
>
> ∴ The relation of A to p is a case of Causation".

7. Relation of Induction to Deduction.—The relation of Induction to Deduction is not one of opposition, but of interdependence.

(1) Induction and Deduction are both necessary in order to arrive at laws of nature. By induction the facts and events of the outside world are collected

by observation and experiment; by deduction we reason upon these facts to discover new truths.

(2) The framing of an hypothesis, which is the second step in an inductive inquiry, involves deduction, for it is by deductive reasoning that we can tell what will be the consequences of the particular hypothesis assumed, *i.e.* how it will fit in with the facts observed.

(3) The Inductive Methods, by which we discover and prove laws of cause and effect, are not purely inductive, but involve deductive reasoning in their practical application to particular cases that have come under observation.

(4) Inductive proofs can be rendered conclusive if they can be confirmed or verified by deductive reasoning, *i.e.*, if it can be shown from a consideration of the nature of the cases that the conclusions can be deduced from laws already known.

Deduction similarly depends on Induction, because the general propositions which constitute the premisses of a deductive syllogism, are obtained by inductive observation and experiment.

Deduction and Induction are therefore only two aspects of the same thing. As Prof. Welton says, "In *Induction*, reality presents itself in concrete and partially isolated instances, and the task of inference

is to discern the universal which is more or less hidden in those instances. In *Deduction*, reality presents itself in its universal aspect, and the task of inference is to trace the presence of the universal in the differing and complex instances of its manifestation. The distinction is therefore solely one of the order in which the two aspects of reality are presented to us".

8. Views of various Logicians as to the Relation between Induction and Deduction.—Venn states and criticises the views of various logicians on the relation between Induction and Deduction :—

(1) **Jevons.**—*Induction is the inverse operation to Deduction.* In Deduction, the premisses are given, and the conclusion has to be obtained ; in Induction, the conclusion is given (in the shape of an hypothesis), and the premisses have to be obtained—*i.e.*, facts have to be collected to prove this hypothesis.

This way of describing Induction is entirely limited to the symbolical or alphabetical treatment of Logic, and is wholly inappropriate to such concrete problems as present themselves in actual life.

(2) **Bacon.**—*Induction is an ascending process, Deduction descending.* By this Bacon means that he who is in possession of an inductive generalisation is like a man on the top of a hill, whereas he who reasons

from universals to particulars is like a man who climbs down a hill.

But this is only a figurative way of describing the relation between Induction and Deduction, and is too vague for scientific purposes.

(3) **Fowler.**—*In Induction we proceed from effects to causes; in Deduction from causes to effects.* But this view is only partially true, for both in induction and in deduction we may as well proceed from causes to effects as from effects to causes. Again, the relation between cause and effect is often a reciprocal one, whereas according to this view it should not be so.

(4) **Buckle.**—*In Induction we reason from facts to ideas; in Deduction from ideas to facts.* This view is incomplete, for in induction we more often reason from facts to facts than from facts to ideas. Also, we sometimes reason from ideas to ideas, not only in induction but also in deduction.

(5) **Other Logicians.**—*Induction is Analysis, Deduction Synthesis.*

This view is a narrow one. Analysis and Synthesis should be understood in a far wider sense. They are general processes, and are not confined to induction and deduction only. The utmost we can say is that Induction makes more use of analysis than does Deduction.

9. Object of Deduction and Induction Explanation of Nature.—The object of every inductive inquiry is the *Explanation* of natural phenomena. The essence of Explanation consists in assimilating a fact to some other fact or facts. Explanation is thus identical with generalisation. The only way of making the obscure plain, or the mysterious intelligible, is to find out *resemblances* among facts, to make different phenomena come under a general notion. It is not *any* sort of resemblance that will suffice for scientific explanation: the resemblance must be fundamental; that is to say, the only satisfactory explanation of concrete things is to discover their likeness to others *in respect of causation*. Hence attempts to explain a phenomenon by familiar comparisons are often worse than useless.

10. Nature of Explanation.—Scientific Explanation consists in harmonising fact with fact, or fact with law, or law with law, so that we may see the two to be cases of one uniform law of causation. For this purpose we have to find fundamental resemblance between the things in question and other things that we already know of; we have to generalise attributes observed in particular cases. *Explanation thus involves generalisation* or induction, and every induction is more or less an explanation of some phenomena.

Since Explanation is the finding of resemblance between the phenomenon in question and other phenomena, *it also involves classification.* But it is always at last an appeal to the primary functions of cognition, discrimination, and assimilation.

The nature of explanation depends in particular cases—

(1) upon the natural soundness of the understanding of the man to whom it is offered;

(2) upon his education; and

(3) upon the nature of the subject-matter; *e.g.* in Mathematics the Explanation of a theorem means its proof, and consists in showing that it repeats, under different conditions, the definitions and axioms already assumed and the theorems already demonstrated. In concrete sciences, to explain a phenomenon means to discover its cause, or to derive an empirical law from laws of causation.

11. **Three forms of Explanation.**—There are three modes of Scientific Explanation :—

(1) The analysis of a phenomenon into the laws of its causes; *e.g.*, the pumping of water may be explained by being analysed into the pressure of the air, the distribution of pressure in a liquid, and the fact that motion follows the line of least resistance.

(2) The discovery of the various intermediate links between an antecedent and a consequent, in other words, tracing remote effects to their causes ; *e.g.*, 'No cats no clover' is explained by supplying the intermediate steps as follows :—The cats destroy the field-mice, which prey on the bees, which, in their turn, are all-important agents in the fertilisation of the clover flowers.

(3) The summing up of several laws under one more general law which includes them all ; *e.g.*, the attraction of the Earth, the motion of the heavenly bodies, the movements of the tides are subsumed under the general law of gravitation.

These three modes of Explanation are respectively known as Analysis, Concatenation, and Subsumption.

12 **Laws Classified.**—To facilitate the work of scientific Explanation, Laws of Nature have been classified, according to their degrees of generality, into the following groups :—

(1) *Axioms or Principles*,—self-evident propositions that are regarded as universally true of phenomena ; *e.g.*, the mathematical axioms.

(2) *Primary Laws of Nature*, which are universally true only of certain forces or properties of matter ; *e.g.*, the Law of Gravitation, the Law of Heredity, the Law of Relativity.

(3) *Secondary Laws*, which are derived from the primary laws, and are sub-divided into—

(*a*) *Derivative*, or those deduced from primary laws ; and

(*b*) *Empirical*, or those that rest upon mere experience.

13. Limits of Explanation.—The explanation of Nature can never be completed, for the following reasons :—

(1) there are fundamental states or processes of consciousness which cannot be generalised under one explanation ; *e.g.* colour, heat, sound, &c ;

(2) there is a perpetual redistribution of matter and energy in the world ; for as soon as we have assigned the causes of the present state of the world, we have to inquire into the causes of those causes, and again the still earlier causes, and so on to infinity ;

(3) every particular fact is itself infinite, so that we may know the laws of many of its properties and yet come far short of understanding it as a whole.

Scientific explanation and inductive generalisation being the same thing, the limits of Explanation are the limits of Induction.

EXERCISES.

1. Name and describe the four stages of an inductive inquiry ; and show that these steps involve deduction.

2. Can the Syllogism not replace the inductive method completely ? Give reasons.

3. Compare Deduction with Induction, and show how far the Inductive Methods are strictly inductive.

4. Describe clearly the relation of Induction to Deduction.

5. Deduction has been called the "inverse operation to Induction", Justify or criticise this view. What other views have been held by logicians on the relation between Deduction and Induction ?

6. What is the object of combining Deduction with Induction ?

7. What is meant by "Explanation" ? How is Explanation related to Induction ?

8. Name and define the three modes of scientific Explanation.

9. Into what groups have laws of nature been classified ?

10. Show that there can be no limit to the explanation of Nature.

11. "Syllogism and Induction correspond to the two great aspects of existence or ways in which things are known". Examine critically the logical implications lying in this Aristotelian doctrine.

CHAPTER IX.

INDUCTIVE FALLACIES.

1. Definition of 'Fallacy'.—"A Fallacy is any failure to fulfil the conditions of proof".

—*Carveth Read.*

"Errors and mistakes in reasoning are called fallacies".

—*Jevons.*

"Fallacies are errors against the laws of reasoning and evidence".

—*Bain.*

"A fallacy is a violation of logical principle disguised under a show of validity".

—*Welton.*

2. Nature of Fallacy.—Any false statement is not a fallacy; for example, a statement like 'Men are in the habit of walking on their heads', cannot be called a "fallacy", because there is no breach of *logical* principles here: at best it can be called an *absurdity* or a piece of stupidity. Similarly, a fallacy should be distinguished from a false belief or a mental confusion, due to prejudice or other similar cause. For example, if an ignorant Hindu believes the *Peepul* tree to be a god, we cannot say that in doing so he commits a fallacy; or if in a moment of fear, a man thinks he has seen a ghost in his bed-curtains, this too is not a fallacy.

There must be a violation of some of the *conditions of proof*, before we can call a statement fallacious.

A fallacy may be committed unintentionally or intentionally to deceive others ; in the former case it is called a *Paralogism*, in the latter, a *Sophism*.

The prolific source of fallacies (of the first kind) is the feelings, emotions, or passions. Men in all ages have been biassed by their interests, their fears, their hopes, their likes and dislikes, their sympathies and antipathies, and even by their moral or religious doctrines. A very interesting discussion of this subject is given in Bain's *Inductive Logic*, Book VI, Chapter III : suffice it for our purposes to point out here a few of the commonest fallacious tendencies of the mind :—

(1) Perhaps the commonest of the commonest is *Self-interest*. Not only does each man endeavour to deceive others, but he generally succeeds in deceiving himself when his interests are at stake. We all have the greatest difficulty in seeing the faults of an institution that is profitable to us.

(2) Our *Sympathies* are also a source of errors. We are commonly disposed to see as much good as possible in our fellow-beings. A similar tendency induces us to believe that the past was the " golden age ".

(3) The illusions of *Hope* are well-known. Men of a sanguine temperament are in the habit of dwelling on the good side of everything, and ignoring the dark side altogether.

(4) *Fear* similarly disposes the mind to dark and dismal views of things. Under the shape of *Superstition*, the susceptibility to fear has held mankind in captivity to innumerable delusions, especially in all that pertains to the supernatural.

(5) In the eye of Logic, *Love* is nothing better than a corrupter of the intellect. The partialities of affection and friendship are notorious.

3. Classification of Fallacies.—Fallacies have been classified in several ways, and according to several different principles. For these various systems of classification, the student must consult his text-book of Deductive Logic. Here we are concerned only with Inductive Fallacies, and these fallacies too have been differently classed by different logicians, but every classification is more or less defective. As Prof. Welton remarks, "A thoroughly satisfactory classification of fallacies is scarcely to be looked for". "There *is*", says De Morgan, "no such thing as a classification of the ways in which men may arrive at an error: it is much to be doubted whether there ever *can be*".

As a specimen of one of these various systems of Classification, we sub-join Mill's :—

FALLACIES.

From evidence distinctly conceived

From evidence indistinctly conceived
4. (*Fallacies of Confusion*).

Inductive Fallacies

Deductive Fallacies
3. (*Fallacies of Ratiocination*).

1. *Fallacies of Observation*

2. *Fallacies of Generalisation.*

The most practical system of classifying Inductive Fallacies is to arrange them into as many divisions as there are divisions of Inductive Logic. This will give us eight kinds of fallacies—(1) Fallacies of Induction, that is, False Generalisation—arising from mistaken views of the nature of inductive inference ; (2) Fallacies of Causation, arising from popular errors as to the nature of cause ; (3) Fallacies of Observation and Experiment ; (4) Fallacies of Classification ; (5) Fallacies of Definition ; (6) Fallacies of Analogy (leading to false Hypothesis) ; (7) Fallacies in the application of the Inductive Methods ; (8) and Fallacies of Explanation. These can, of course, be arranged under fewer heads, but even at the risk of some want of method we shall prefer to treat them

one by one in the order in which they have been enumerated above.

I.—FALSE GENERALISATION.

In one sense all Inductive Fallacies may be regarded as fallacies of generalisation, since generalisation is involved in every process of induction. Whenever a general statement of any kind is made, for which the evidence is logically insufficient, we commit a fallacy of generalisation.

Fallacies of Generalisation are the commonest kind of fallacies. This is because the human mind is naturally disposed to generalise its experience somewhat too hastily ; and on the other hand, caution in making general statements is one of the surest marks of the exact thinker—the *logical* mind. The following are the chief ways in which a fallacy of generalisation may be committed :—

(1) *By extending propositions which hold good only of the world, to remote parts of the universe where no observation or verification can be carried* ; *e.g.*, to reason as though there were a geographical heaven and hell, and to describe it in terms of the mode of life on earth.

(2) *By theories professing to resolve all things into some one element* ; *e.g.*, the theory that professes to

explain all mental states of thinking, feeling, and willing as modifications of the nervous system.

(3) *By supposing or inferring Causation without attempting to prove it.* Such fallacies are known as Fallacies of Causation, and they will be treated separately in the following section.

II.—FALSE CAUSATION.

We saw in Chapter II how difficult and intricate the conception of Cause is, and errors in the matter of causation are therefore more frequent and more subtle than any other class of errors. The popular notion of Cause serves only to multiply such errors, which include those arising from the popular devotion to the goddess of Chance. According to the popular view, anything may be the cause of anything else; but according to the scientific view the cause of an event is its immediate, unconditional, invariable antecedent.

The Fallacies of Causation have already been enumerated in Para. 18 of Chapter II; we shall here recapitulate them with illustrations :—

1. **Assigning the cause of anything that is not a concrete event.**—For example, we cannot speak of enquiring into the *cause* of why two circles can touch only in one point: we can only give the *reason* of such a fact, because the fact is not a concrete event. Simi-

larly we cannot seek the cause of why two and two make four, or why the two sides of a triangle are together greater than the third, though these hold true *in all cases*,—because these are not concrete facts, but abstract mathematical problems.

2. Seeking the cause of the universe as a whole.—Carveth Read calls this the "fallacy of transcendent inference". The limit of Induction are facts and events that are within the reach of human inquiry: it cannot extend to regard events too vast for man's comprehension. Induction also deals with events that can be compared : it cannot deal with that which is unique. All inquiries as to whether the universe was created by a Supreme Intelligence or whether it originated in a fortuitous concourse of atoms, are therefore beyond the province of Induction, and must be conducted by *a priori* reasoning exclusively.

3 Mistaking Co-existence for causation.—*e.g.* when a man wearing an amulet escapes from the plague and regards the amulet as the cause of his escape. Or, because the body and the mind dwell together it should not be argued that either is the cause of the other.

4. Mistaking Causation for Co-existence.—*e.g.* to think that it is a matter of accident that great rivers generally flow past great cities ; or that tropical birds

have bright plumage ; or that hill stations are cooler than cities in the plains.

5 **Mistaking mere sequence for causation.**—This fallacy is commonly known as "*Post hoc, ergo propter hoc*", and it is a very common error. Superstitions afford plentiful instances of this fallacy ; *e.g.*, a man starts on a journey on a Thursday afternoon and meets a mishap on the way, and attributes it to the Thursday afternoon. The appearance of a comet is supposed to cause famines, plagues, earthquakes, and other disasters. Travelling in a northerly direction on a Tuesday or Wednesday is believed, by ignorant Hindus, to be unlucky. Dreams dreamt in the small hours of the morning are believed to come true. Certain conjunctions of planets are supposed to be favorable or unfavorable to persons born "under the influence" of particular stars ; and so on and so on.

6. **Mistaking the Co-effects of a common cause as standing in the direct relation of cause and effect.**—For example, the establishment of a religious society in a particular district may be followed by a decrease in crime, and yet both these may be due to the same cause—the spread of education. For example, again, the flow-tide always precedes the ebb-tide and is equal to it, and yet one is not the cause of the other, both being caused by the attraction of the moon.

7. Mistaking one condition of a phenomenon for the whole cause.—For example, to say that the numerous Bank failures that took place in India recently, were caused by panic, is only true if we use 'cause' in the popular sense; or to say that a temperature of 32° F. is the cause of the freezing of water.

8. Mistaking a single consequence for the whole effect.—For example, to think that the setting up of an alms-house will relieve distress in a district; that fatigue will be removed by taking a stimulant; that protective duties will encourage industry, are all fallacies of this type. For the effect of each of these events will be more than the single consequence named. The alms-house will not only relieve distress, but also encourage idleness and pretence; the stimulant will remove fatigue, but will produce nervous depression that may be followed by various consequences of its own; protective duties will not only encourage industry, but also laziness, by removing the stimulus of healthy competition.

9. Treating a remote condition as an unconditional one.—For example, to say that Napoleon's Russian campaign was the cause of his downfall; that the imposition of the Jazia by Aurangzeb was what brought about the ruin of the Moghal Empire; or to say that the present triumph of European civilisation was really due

to the Greek victory at Marathon, are all fallacies in which one single condition, and that too a remote one, has been supposed to make up the whole cause.

10. Neglecting the negative conditions of a cause.—We have seen (in Chapter II) that the cause is the sum of the positive and negative conditions; and so if we take account only of the positive conditions, and ignore the negative ones, we commit a fallacy. For example, to say that "water boils at a temperature of 212° F." is not scientifically accurate, for we have to add the negative condition, "provided the pressure of the air be the same as at sea-level"; or to say that "an increase in the supply of a commodity will cause a fall in its price" is also fallacious, for we have to specify the negative conditions, viz., 'provided there is no increase in the demand' &c. Hence in all economic laws there is a condition invariably attached "other things being equal". In every case of causation due account must be taken of what are called "counteracting causes", and whenever this is not done the result is a fallacy.

11. Placing Empirical Laws on the same footing of certainty as those of Cause and Effect.—For example, statements like the following are all based on mere experience, and not on the law of Causation :—'Men of high destinies have high-sounding names';

'No man is a prophet in his own country'; 'Every increase in a man's income causes an increase in his happiness'; 'Vaishnavas are the meekest of Hindu sects'; 'The longest-lived men belong always to the priestly class'; &c.

12. **Confusion between Cause and Effect owing to their interaction.**—Cause and effect being quantitatively equal, the relation between the two is often reciprocal, especially when both last for a long time. For example:—Industry produces wealth, and the acquisition of wealth causes industry; Habits of study sharpen the understanding, and the increased sharpness of the understanding may afterwards confirm these habits of study; Excess of population may, by impoverishing the labouring classes, be the cause of their living in bad dwellings, and again bad dwellings, by deteriorating the morals of the poor, may increase population; Drunkenness is due to stupidity and stupidity results from drunkenness.

III.—FALLACIES OF OBSERVATION.

As all inductive inference starts from concrete phenomena, and continually returns to concrete phenomena, as the test of accuracy, it is evident that its validity depends directly upon the correctness and perfection of the observations of fact upon which it is based.

A Fallacy of Observation does not mean a violation of any of the rules for watching facts or events,—for Logic lays down no rules for observation; it means any omission or partiality in collecting facts with a view to the generalising process.

Fallacies of Observation are of the following varieties, according as they result from—

1. Non-observation of particular instances.—This consists in overlooking or omitting to notice facts or particulars which ought to have been observed. For example, objects immersed in water appear magnified, but from this we do not conclude that they *become* magnified. Another instance of this fallacy may be noticed in the proverb, 'Think of the devil and the devil is before you'. This is based on the observation of many cases in which the mention of a person's name during his absence has been immediately followed by his suddenly turning up at the place. The error in the statement consists in the *non-observation* of the many more instances in which this has not happened. A third instance of this fallacy is to assert that because a phenomenon has never been observed that therefore it is necessarily non-existent.

2. Non-observation of important conditions.—This fallacy consists in taking note of the immaterial

or irrelevant conditions of a phenomenon and overlooking the essential conditions. For example, those who believed in Kenelm Digby's "Sympathetic cure", which consisted in applying an ointment to the weapon which caused a wound instead of to the wound itself, committed this fallacy, because they overlooked the essential circumstance that nature was left to her own devices for effecting a cure. Secondly, those who say that an increase in the number of convictions for any particular crime necessarily shows an actual increase in that crime, also commit this fallacy, for they do not notice the important fact how far the larger returns were due to greater vigilance on the part of the police. Take another example. Suppose *A* spends the whole of his income in expensive living, and is supposed to give great employment to labour; *B*, who lives moderately, invests a great deal of his money in profitable concerns, and is thought to give little or no employment. This is a fallacy, for *B's* money goes to support a number of industries giving employment to thousands of workmen, and this is not directly visible.

3. **Mal-observation.**—This consists in giving a false interpretation to our sensations,—in observing a thing wrong. For example, we think we *see* the sun rise and set, and conclude that the sun moves round

the Earth. The moon at rising and setting appears much larger than when high up in the sky : this is the effect of the intervening atmosphere, not a difference in the actual size of the moon. Ventriloquism is another instance of mal-observation : as a voice which comes from the vocal organs of the ventriloquist seems by a minister-pretation to issue from an inanimate and motionless object.

Fallacies of Experiment are the same as fallacies of observation. Mistakes in conducting experiments may arise from neglect of any of the following processes :—

(*a*) repeating experiments as often as may be necessary,
(*b*) averaging them properly,
(*c*) verifying one experiment by another,
(*d*) refining the methods of exact measurement.

IV.—FALLACIES OF CLASSIFICATION.

Fallacies of Classification consist in bringing together under one group or under one name, things that have no common properties ; *e.g.*, to call all black birds "a kind of crow", or all white birds "a kind of swan", or an airship, "a class of ship".

Fallacies of Classification arise from a breach of one of the rules of Logical Division. It has already

been pointed out in Chapter IV that the tests of a good Classification are the same as the tests of a Logical Division, especially the rule that the sub-classes must be mutually exclusive. The commonest kind of faulty Division is Cross Division ; in the same way the commonest kind of defective Classification is one in which a group is counted twice. Such a classification would confound the very idea of specific distinctions which is the essential idea in a classification.

The best example of defective classification is the old classification of the Virtues into Justice, Prudence, Courage and Temperance : for prudence includes the whole of temperance as well as that part of courage that conduces to self-interest.

Another famous example of fallacious classification is the division of mental states into Knowing, Feeling, and Willing. This is a cross division at every step. for knowing is not possible without some kind of feeling, say, in the shape of interest, and without some kind of willing, if only in the shape of attention. Again, feeling is not possible unless we know the thing which excites the feeling : and so on.

Fallacies may also arise from confusing classification with mental analysis, or concrete partition, or dismemberment. For example, we may separately attend to the form, the size, the brilliancy, and the

weight of a diamond; but a diamond cannot be "classified" into these qualities. Similarly, a Classification should be distinguished from the physical division of a whole into aggregate parts: *e.g.*, the different parts of a house—the foundations, the walls, the roof, &c.—do not make up a "classification".

Fallacies may also result from dividing a whole on trivial or insignificant characters, as if we were to "classify" an army or the population of a town into persons with names of one syllable, and persons with names of more than one syllable.

V. FALLACIES OF DEFINITION.

Fallacies of Definition arise, like fallacies of Classification, from a violation of any of the rules of Definition. Definition, as we have seen in Chapter IV, consists in fixing by language the precise signification—*i.e.*, the connotation—of general names. Defining does not therefore apply to the unmeaning name, or to the Proper name. An arbitrary name used for a particular object, as "Kalloo" for a dog, or "Fairy Queen" for a locomotive engine, or "Calmopal" for a house, cannot be "defined" in the proper sense of the term. It may, however, be "described" by being represented and marked off from all other things by a series of suggestive names of general signification.

For example, we may say that 'Calmopal' is "a broad-fronted *pucca* house, on the Eastern Canal Road, Dehra Dun, in which the Alexandra Hotel used to be located". This is a *description*, and not a definition.

A perfect definition is the *whole* connotation of the name defined. The singling out of one or two properties, for the mere purpose of discrimination, is not a proper definition. For example, an 'airship' is not accurately defined by being called 'a mechanism for flying through the atmosphere'.

To give a good definition of a thing is one of the most difficult of intellectual tasks. It is much easier to criticise a definition than to frame a new one.

This difficulty is further increased by the fact that a name originally applied to one thing, may, by association, be transferred to another, or come to have an extended meaning. The word 'letter', for example, has undergone a series of transitions. Originally applied to the alphabetic characters, it passed to epistolary correspondence, and then to literature; and it retains all these meanings still. The word 'gentleman' is an example of transitions growing out of historical and political circumstances. "Meaning originally a man born in a certain rank it came by degrees to connote all such qualities as were usually found to belong to persons of that rank. This consideration explains why in one of

its vulgar acceptations it means any one who lived without labour, in another without manual labour, and in its more elevated signification it has in every age signified the conduct, character, habits and outward appearance, in whomsoever found, which, according to the ideas of that age, belonged or were expected to belong to persons born and educated in a high social position".

To test definitions the best thing is to apply the Rules of Definition given in Text-books of Deductive Logic.

VI.—FALSE ANALOGY.

A False Analogy is a comparison in which there is little or no real resemblance. There are three varieties of this fallacy :—

1. **Wrongly estimating the force of a Comparison.**—This fallacy occurs whenever in a comparison the points of resemblance are allowed too much weight relatively to the points of difference with which they are bound up. In such a case the comparison is found to break down in detailed application. A familiar example of this kind of false analogy is the comparison of the history of a nation to the life of man, in respect of birth, growth, maturity and decay. The comparison cannot, however, be pushed any further. A nation's

losses are repaired: the physical failure of a human being is irreparable.

2. **Missing the exact bearing of a comparison.** – In this case, points of resemblance, which are important relatively to one purpose, are made the basis of an analogy directed to another purpose. Welton quotes as an instance a passage from Plato's *Republic*: "If justice consists in keeping property safe, the just man must be a kind of thief: for the same kind of skill which enables a man to defend property will also enable him to steal it". The weak point of this analogy is that though the *capacity* of preserving property may be identical with the capacity of appropriating it, the *act* of preserving it is very different from the act of appropriating.

3. **Use of figurative language.** In the use of figurative language the error often consists in assuming the existence of an analogy where none exists. Thus, for instance, the speaking of a 'mother-country' in relation to colonies may lead to the inference that the relations of a colony to the mother-country are the same as those of children to their mother, and hence to the inference that it is the duty of the mother-country to support her colonies. Other points of difference will also suggest themselves in the two relations.

A similar instance of false analogy due to figurative language is to compare the metropolis to the 'head' or 'heart' of the body, and to argue that, just as any abnormal increase in these members points to disease in the natural body, similar diseases will follow in the state if the capital of the country becomes very large.

Other examples of false analogy are to compare the governor of a country to a pilot. Scott, in his *Marmion*, compares Pitt to a pilot or helmsman, when he says that Pitt—

'With dying hand the rudder held'.

VII.—FALLACIES IN THE APPLICATION OF THE INDUCTIVE METHODS.

Fallacies resulting from the incorrect application of the Inductive Methods, are the same as fallacies of generalisation,—only that the direct occasion of the error in the former cases is due to insufficient elimination or improper application of the Canons. These fallacies are at bottom fallacies of causation, because the main object of the Methods is to determine causal connection between phenomena.

A detailed account of fallacies resulting from the wrong application of the Inductive Methods would be but a mere repetition of the foregoing chapters. Hence all that will be done here is briefly to indicate the main sources of error under each of the Inductive Methods.

1.—THE METHOD OF AGREEMENT.

The main sources of fallacy under this head are:—

(1) Observing an insufficient number of instances; as when a man seeing a few of his educated friends discontented, argues that education makes people discontented.

(2) Taking note of irrelevant or unessential points of agreement; as when a man noticing that all Chinamen wear pig-tails, should conclude that the pig-tail is the cause of the excellence of Chinese art.

(3) Neglecting to take note of a possible plurality of causes and intermixture of effects: as when a man finding that some countries adopt a gold standard should argue that the gold standard alone was the cause of their prosperity. The prosperity or decline of whole countries is a very complex phenomenon that cannot be explained by single causes like these. Also the term 'prosperity' means the sum of the multiple effects of a variety of causes: it includes, for instance, progress in education, trade and commerce, products and industries, army and navy, &c.: and all these cannot evidently be due to one sole-sufficing cause.

2. THE METHOD OF DIFFERENCE.

The chief source of fallacy here is to believe that we have got two instances of a phenomenon that are

exactly alike, except for one circumstance, when as a matter of fact, the resemblance between the two is not so close.

Suppose that on instituting a comparison between Eastern and Western Bengal we find that these two tracts of country are exactly alike in physical features, in climate, in population, in products and industries, in trade and commerce, &c., and that the only point of difference between the two is that in one province education is backward, in the other not. To apply the method of difference, we carry on further inquiries and find that the staple food of Eastern Bengal is rice, whereas that of Western Bengal, rice and wheat in equal proportions. Shall we be right in saying that it is the difference in the staple food that accounts for the difference in the state of education in the two provinces? Or could we, by the "experiment" of introducing wheat into Eastern Bengal, improve its educational system?

3.—THE JOINT METHOD OF AGREEMENT AND DIFFERENCE.

The fallacies arising under this Method are the same as under the Method of Agreement. Also, since this method relies chiefly on observation it is exposed to all the risks to which the process of observation is exposed. (*Vide* III. "Fallacies of Observation".)

For example, on examining a number of educated people we come to the hypothesis that education makes people *discontented* ; and to confirm this hypothesis we examine a few negative instances—*i.e.*, people who are uneducated; and suppose we find that they are *contented.* Shall we be right in supposing that our hypothesis is correct ? No ; for we might have erred both in the first case and in the second. The people whom we thought to be discontented were probably more truly contented than the ignorant herd whom we supposed to be happy in their ignorance.

4.—THE METHOD OF CONCOMITANT VARIATIONS.

The chief sources of fallacy in the application of this method are :—

(1) Mistaking qualitative variations for quantitative ones ; *e.g*, if with concomitant changes of weather the water vapour in the air assumes the form first of dew, then of mist, then of fog, then of cloud, then of rain, we cannot apply this Method at all.

(2) Applying the method to cases that can never come under observation ; *e.g.*, it is the movement of the Earth on its orbit that causes the revolution of the seasons ; and this movement is at a certain uniform rate : we cannot argue from this as to what would happen if this motion were to be performed at a continually accelerated rate.

(3) To argue indefinitely according to this method; *e.g.*, the distinctness of a sensation is in proportion to the intensity of a stimulus; we cannot argue that if the intensity of a stimulus, say of sound, were increased a thousand times more than what is necessary to make the sound audible, the sound would become a thousand times more distinct; because in such a case what would happen is that the auditory organs would be permanently injured.

(4) Failing to notice that two phenomena varying together may be joint effects of a common cause: *e.g.*, in proportion as the religious faculty is strong in men their moral faculty gains strength also: but from this we cannot infer that the strength of the one is caused by the strength of the other: for the strength of both faculties may really be due to the influence of education.

5.—THE METHOD OF RESIDUES.

The chief fallacies under this head result from supposing that the application of the Method of Residues is as easy as working a sum in simple subtraction. The study of residuary phenomena is a most difficult study, implying as it does an accurate knowledge of all that has been said or written on every branch of the phenomena. For example, if we were

to inquire whether there is in man a separate moral faculty by the Method of Residues, that would mean that we can satisfactorily explain all other things that are in man's nature, except the existence of a Conscience which judges between right and wrong. But man's nature is a subject that man, in all the centuries of his existence, has not yet been able fully to understand.

VIII.—FALLACIES OF EXPLANATION.

There are three varieties of this fallacy :—

(1) Repeating a fact in different language ; *e.g.*, to say that opium produces sleep because it possesses a soporific virtue, may be an excellent paraphrase, but not a scientific explanation.

(2) Regarding a phenomenon as simple only because it is familiar ; *e.g.*, to explain "combustion" as simply the process of burning is no explanation.

(3) Supposing without sufficient grounds that an ultimate law of nature is really not ultimate, but secondary ; *e.g.*, to suppose that Gravitation is due to some more general law is a fallacy of this kind.

MISCELLANEOUS EXERCISES ON INDUCTIVE FALLACIES.

HINTS FOR THE EXAMINATION OF ARGUMENTS.

1. The examination of arguments with a view to detecting if they contain any fallacy, is a matter requiring the greatest care: there are few departments of Logic which present greater difficulties to students than this.

2. If you are required to point out the fallacy in any argument, an analysis will very frequently reveal the fact that it may legitimately be classed under several heads. But you must bear in mind that it is not in correctly *naming* a fallacy, or giving a list of them, but in offering correct *reasons* for the error, that the virtue of an answer inheres.

3. If an argument falls under more heads of fallacy than one, it is advisable to point out all of them.

4. Specify as nearly as possible the exact error committed. If you cannot call up the technical name of a particular fallacy, it is better not to give any name at all than to give a wrong name.

5. But you should, before proceeding to work out any Exercises on Fallacies, make yourself familiar with all the technical names of kinds of fallacy.

6. Above all, you must remember that every argument offered for criticism is not necessarily fallacious.

EXERCISES.

1. Illustrate any one of Mill's Experimental Methods by pplying it to the investigation of two of the following questions :—

(1) the effects of playing cricket on health ;

(2) the causes of the Plague ;

(3) the risein the prices of things.

2. What is the nature of the following argument :—

A College has gone up in numbers. Its situation is unhanged ; the fees are the same ; the system of teaching is unchangd ; the staff and management are the same ; therefore the increase must be due to the succession of a new Principal.

3. What inference can you draw from the following facts, nd by which of the Methods ?

(*a*) Five out of the seven schools of Allahabad show an extremely good result at the Matriculation Examination. It is found that in all these schools the attendance of scholars was extremely regular.

(*b*) There are two wards for indoor patients in a certain hospital, one facing north, and the other south. The health of the patients in the latter ward is good, but the death-rate is high in the former.

(*c*) In a public library the proportion of novels to other works was 1 : 9 in a certain year : 1 : 5 the next year ; and 1 : 12 the year after. The number of readers was largest in the second year and smallest in the third.

(*d*) In 1910 the earnings of the O. R. R. from third class passenger fares was one lac of rupees in excess of those derived from other classes ; in 1911 the excess was $1\frac{1}{4}$ lac : in 1912 it was $1\frac{1}{2}$ lacs ; and in 1913 it was $1\frac{3}{4}$ lacs.

(*e*) The portion of Lucknow on the north side of the Gumti is much healthier than that on the south side of the river, there being no difference in the sanitation or population of the two portions.

4. What Inductive Methods are involved in the following examples :—

(*a*) The nearer all bodies approach to the earth, the greater is the velocity with which they approach it ; but the farther they are, the less is the force with which they tend to approach it ; we may therefore infer that their greater (or less) nearness to the earth is the cause of their increased (or diminished) velocity.

(*b*) A, B, C, D, and E were the members of the committee which rejected my friend. I know that A, B, C, and D did vote for him, so that he must have been black-balled by E.

(*c*) When heat is applied to a thermometer, the mercury first falls a little, then rises. Since only the rise is caused by the expansion of the mercury, the fall must be due to some other cause, *i.e.*, the expansion of the glass tube by the heat.

(*d*) By noticing carefully on what nights dew is or is not deposited, we discover that a clear sky is an indispensable condition of its formation.

(*e*) It is observed that those polished substances are most strongly dewed which conduct heat worst : while those which conduct heat well resist dew most effectually.

(*f*) A guinea and a feather dropped together from the top of a glass vessel which has been rendered vacuum, reach

the bottom at the same moment. In the air the guinea drops much faster.

(g) Many cases of malarial fever are found to agree only in that the sufferers have been bitten by a mosquito; therefore mosquitoes are the cause of malaria.

5. Examine the following arguments :—

(a) Sanatogen has proved a most efficacious remedy to many of the most distinguished men and women of Europe. It is likely therefore that it will prove useful in my case.

(b) A Hindu gentleman comes before me : I know he is not a Brahman, nor a Kshattriya, nor a Vaishya, and I conclude he must be a Sudra.

(c) A boy hears that he has passed the Matriculation Examination. He knows full well he could not have passed either in Class I or in Class II : and he concludes that he has passed in Class III.

(d) More students failed in Logic in 1914 than in any previous year. The syllabus has all along been the same; there is no reason to believe that the standard of teaching has gone down; the nature of the questions set has also been practically the same; the average intellect of the students has not declined. The heavy failure must therefore be due to a new Examiner.

(e) The Hundred Years' War was a struggle between France and England, and it lasted for a very long time, as its very name shows. From this it could have been inferred that the Napoleonic Wars would continue for many years.

6. What inference can you draw from the following facts, assuming that the observation was correct :—

(a) All male birds have bright feathers, all females, dull.

(b) Buffalo-milk contains a greater proportion of *ghee* than cow's milk.

(c) It has been observed that of all castes *kahärs* furnish the largest percentage of men for domestic service in the U. P.

(d) Careful observation reveals the fact that those who take meat food have bad teeth, while vegetarians have as a rule strong teeth.

(e) Nepal and Bhutan are perfectly alike in all respects, except that the former is more mountainous and therefore a little colder than the latter. The people of the two countries are likewise of the same stock, the same stature, the same habits ; but the Nepalese are a shade fairer in complexion than the Bhutanese.

7. Examine the following arguments :—

(a) A boy on his way to the Examination-hall sees a *Nil-kanth* (a jay). He had heard before from his parents that the Nil-kanth was a very auspicious bird, sacred to the god Shiva. A few weeks later he hears that he has passed his Examination, and he at once attributes his success to the Nil-kanth.

(b) Proximity to the sea is a cause of heavy rainfall, for we see that in Calcutta, Bombay, Madras, Karachi the rainfall is heavy.

(c) The fruits of tropical countries are far sweeter than those of temperate regions. Heat is therefore the cause of the sweetness.

(*d*) Sherlock Holmes says to Dr. Watson : "*Observation* shows me that you have been to Wigmore Street Post Office this morning. For I see there is some red mud on your boot, and there is some red mud of a similar kind in front of the post-office, and, so far as I have observed, nowhere else in the neighbourhood".

(*e*) Halley's comet appeared in 1910, and the same year, in fact,. the same month, our gracious King-Emperor Edward VII. of beloved memory died.

What Shakespeare says is therefore perfectly true :

"When beggars die there are no comets seen,
The heavens themselves blaze forth the death of princes".

8. What logical inference can you draw from the following :—

(*a*) "In all unhealthy countries the greatest risk of fever is run by sleeping on shore. Is this owing to the state of the body during sleep, or to a greater abundance of miasma at such times ? It appears certain that those who stay on board a vessel, though anchored at only a short distance from the coast, generally suffer less than those actually on shore".

(—*Darwin*).

(*b*) Plague Doctors have observed that out of every hundred seizures some ninety prove fatal.

9. What inference can you draw from the following circumstances, and according to what method ? Will such an inference be conclusive ? If not, how would you make it conclusive ?—

"I have of late," says a physician "from time to time risen with a headache in the morning, for which I cannot account. Somehow I fancy that it must be connected with some sort of digestive

disarrangement, and that this disarrangement is the result of some food which I have taken and which does not suit my stomach. One day it occurs to me that my headache always follows a special diet, and that possibly this may be its cause. I therefore take note of what I have for dinner, and after a little experience I discover that in most cases when I have eaten jugged hare for dinner I have a headache the next morning. I set to work to test the connections. First of all I take a number of days when my dinner has been as varied as possible. On one day I have taken soup, on another day none. On one day I have had rice, on another bread, on another mutton. One day I have drunk port wine, on another sherry, on another champagne, on another hock, on another nothing but water. But on all these days there has been jugged hare, and on each of them there has been a headache following".

10. What fallacy, if any, is involved in the following inference :—

I happen to be staying in an hotel in Madras where I make the acquaintance of a Madrasi gentleman. I find him not only most courteous and kind, but full of information and an excellent master of English. His talents in this respect make such an impression on me that I unconsciously argue that all Madrasi gentlemen are good scholars of English.

11. Can we argue that because the body of one man is liable to disease, therefore the body of some other man is exposed to the same malady ? If we do, what kind of argument would it be ? And would such an argument be strong ?

12. Criticise or justify the following instances of Causation :—

(*a*) I walk under a ladder and miss the train just afterwards : I attribute my misfortune to the ill-luck resulting from going under a ladder.

(b) A ship sails on a Friday and is shipwrecked, and one of the passengers blames his folly in starting on an unlucky day.

(c) An habitual drunkard accounts for his shattered nerves by the fact that he studied hard at the University in his youth.

13. What inference can you draw from the following fact :—

Near Naples there is a very curious cave, called the Grotto del Cane. Men can walk safely into it, but dogs when they enter soon fall down and die, unless quickly removed.

(*Jevons*).

14. If a person in perfect health falls down stairs, and receives severe injuries, followed by death, can we feel sure that the fall caused the death ?

If the same happens to a man seized with some kind of fit, will the inference be different ? Give reasons for both.

15. Can you draw any inference from the following well-known fact :—

When air is forced into a fire by use of the bellows, greater heat is produced ; the more powerfully we blow, the hotter the fire becomes, and as soon as we leave off blowing the fire begins to cool.

16. Supposing a house to be burnt down, mention all the antecedents and consequents you can think of, and point out those antecedents which might be causes.

17. " The carpet of a room becomes faded, how would you attempt to ascertain whether this is due to the air, or the fire (in the chimney), or people walking on it, or by some cause of change in the carpet itself " ?

(—*Jevons.*)

18. " A healthy person who walks briskly in a sheltered place does not feel cold even when the air is very cold. How would you ascertain by experiment whether his feeling warm is due to exercise, or to shelter, or to both " ?

(—*Jevons.*)

19. " If on looking into a manufactory you see two wheels, one of which always moves or stops when the other moves or stops, what would you infer about them, and by what mode of reasoning " ?

(—*Jevons.*)

20. " The Nile by overflowing its banks enriches the neighbouring country : therefore the Po by overflowing its banks will enrich the neighbouring country. What do you think of this argument " ?

(—*Jevons.*)

21. Well water needs more soap in washing than pipe water. This is because well water is " hard," whereas pipe water is " soft ". What sort of explanation is this ?

22. Is there any logical inference in the following cases :—

(*a*) Travellers sometimes make a rapid journey by railway through a foreign country, and then come home and write a book. They judge of millions of people by the few that they get to know in hotels or public conveyances.

(*b*) The savages living on the shores of New Guinea have probably been ill-treated by the crews of trading vessels. Hence they are very unfriendly to strangers.

23. What Inductive Method is applicable to the following case :—

If a Spring-tide due to the attraction of sun and moon, is twelve feet at a certain place, and we know that an ordinary tide,

due to the moon alone, is eleven feet, we conclude that the sun's attraction causes a rise of one foot.

24. What fallacy is committed in the following :—

The father of a dumb girl wanted to know why his daughter was dumb. "Nothing is more easy than to explain it", said the physician; "it comes from her having lost the power of speech". "Yes, yes", objects the father, "but the cause, if you please, why she has lost the power of speech". The physician was quite ready with a more accurate explanation: "All our best authors will tell you that it is the impeding of the action of the tongue".

(Jevons, quoting Moliere).

25. A number of cholera cases agree in nothing but that all the patients used the same milk. What conditions must be presupposed to enable us to draw a valid inference from this fact?

26. It has been observed that the spots on the sun and storms on earth increase and decrease at the same periods. Can we establish any connection between these two phenomena, and if so, by what method? Give reasons.

27. "The marks on the rocks in Cumberland are explained as having been produced by glaciers, because these marks are the same as those now made by glaciers in Switzerland". What sort of reasoning have we here? Do you think it is sound?

28. The night that Oliver Cromwell died, a great storm devastated London. What sort of fact would you call this? And can you draw any inference from such a fact?

29. Can you draw any inference, and if so of what kind, from the following premisses :—

"A great many Hindus are worshippers of Shiva;
A great many Hindus are educated".

30. The temperature of the interior of the Earth increases, as we descend, at a nearly uniform rate of one degree to fifty feet of descent. Does this fact furnish any basis for an inference? If so, upto what limit, and according to what principle?

31. What kind of statements are the following, and how far are they reliable :—

(*a*) About 250 persons in a year commit suicide in London.

(*b*) The tops of very high mountains are covered with snow.

(*c*) Quinine cures a fit of ague.

(*d*) The sun will rise to-morrow.

32. Under what head of fallacy would you class the following, and why :—

The Greek philosopher Thales imagined that all phenomena whatsoever were at bottom merely the many-sidedness of a single central power—viz., Water.

33. Is the hypothesis that Dreams are supernatural creatures sent down by the Angel of Sleep, a correct hypothesis? Give full reasons.

34. What kind of supposition is the supposition of an etherial substance pervading all space, and by its undulations propagating Light and Heat, as the air propagates sound?

35. What kind of supposition is the supposition of an original "Social Contract" determining the rights of sovereignty?

36. What kind of assertions are the following? Examine them logically :—

(*a*) The more haste, the less speed.

(*b*) Honesty is the best policy.

(*c*) Knowledge is virtue.

37. The balsam of Peru possesses certain properties, medicinal or other; the balsam of Tolu agrees in a great number of these, but differs in one or two important or unimportant properties. Will a chemist at a dispensary be justified in substituting the one for the other in dispensing a doctor's prescription ?

38. Every hot body on the earth cools by radiation: can we infer from this that the sun too is gradually cooling ?

39. "I remember as a boy lying on the grass on a summer's day looking up into the sky. I saw, as I thought, a very big bird very high up in the air. In another moment I found that I was mistaken and that what had really happened was that a very small fly had passed quite close to the eye". (*Stock*).

What was the nature of this "mistake" ?

40. In reading English Grammar we find that all infinitives, simple and gerundial, are preceded by 'to' expressed or understood. How far may the word 'to' be spoken of as the cause of an infinitive ?

41. "Berkeley discovered that tar-water had the effect of preventing small-pox. He tried it in his own neighbourhood when the small-pox raged with great violence. 'And the trial', he says, 'fully answered my expectation: all those within my knowledge who took the tar-water having either escaped that distemper, or had it very favourably. In one family there was a remarkable instance of seven children, who came all very well through the small-pox except one young child which could not be brought to drink tar-water as the rest had done".

(*Stock.*)

What sort of inference have we in the above ? Discuss fully the validity of it.

42. "One Sunday morning in a poor country parish there appears the phenomenon of a half sovereign in the offertory: the clergyman knows by repeated experience that none of his flock ever by any chance give more than a silver threepenny, but he has perceived a stranger present in the congregation". What inference would be drawn, and by what method?

43. A student works hard for an Examination, but fails. Can he legitimately draw the conclusion that hard work brings on failure?

44. A gentleman driving down a street one dark night comes into collision with a lampless lamp post and sustains some injuries. How far was the darkness, and how far the lamp-post contributory causes of the accident?

45. Seasons of famine are in India very often succeeded by seasons of cholera. Can you trace any causal connection between these two phenomena?

46. In many of the towns of the U. P. it has been observed that some wells contain sweet water, others brackish. The brackish ones are as a rule situated in those quarters which have been inhabited for many generations; the sweet ones, in portions newly settled. What inference can you draw from the above, and by what method?

47. We notice that in India tea cultivation is carried on only in hilly tracts of country. Does this afford any basis for inference? If so, how?

48. In all countries the rule is that as manufacture flourishes, agriculture declines. Is there any causal connection between the two?

49. Boys who were very precocious in early age are known to have grown dull subsequently. Does this warrant us in drawing a universal conclusion, or any conclusion at all ?

50. A young student, after finishing his course in Deductive and Inductive Logic, proposed to amend the definition of Logic by calling it "the most charming comedy of errors". How far was this definition inspired by logical acumen and how far by youthful admiration ?

[FINIS.]

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